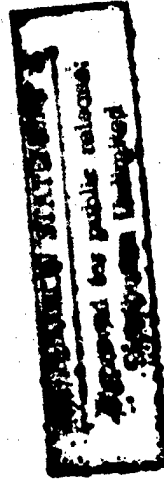


UNCLASSIFIED

# FY 2000/2001 Budget Estimate Submission DESCRIPTIVE SUMMARIES

*September 15, 1998*



19981019006

Defense Advanced Research Projects Agency



UNCLASSIFIED

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# DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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# **SECTION I**

## **FUNDING SUMMARIES**

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY  
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSEWIDE  
PE/PROJECT LEVEL SUMMARY REPORT**

(\$ in millions)

PE	PROJ	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
61101E	CCS-02	INFORMATION SCIENCES			20.100	19.500	19.700	19.700	20.700	21.700
	ES-01	ELECTRONIC SCIENCES	16.376	18.899	20.100	30.583	30.433	36.183	37.183	38.183
	MS-01	MATERIALS SCIENCES	36.192	20.512	22.910	19.953	21.053	21.053	22.053	23.053
			14.125	25.691	22.390					
	61101E	DEFENSE RESEARCH SCIENCES	66.693	65.102	65.400	70.036	71.186	76.936	79.936	82.936
62110E	NGI-01	NEXT GENERATION INTERNET	39.028	40.000	40.000	0.000	0.000	0.000	0.000	0.000
62301E	ST-01	JASONS	1.289	1.200	1.200	1.200	1.200	1.200	1.200	1.200
	ST-11	INTELLIGENT SYSTEMS & SOFTWARE	86.695	76.144	78.299	72.656	63.926	71.591	76.591	70.391
	ST-19	HIGH PERFORMANCE AND GLOBAL SCALE SYSTEMS	149.462	196.483	172.863	183.595	191.727	198.329	200.329	203.329
	ST-22	SOFTWARE ENGINEERING TECHNOLOGY	16.609	17.100	17.600	18.100	18.700	19.300	19.300	19.300
	ST-24	INFORMATION SURVIVABILITY	40.343	56.896	58.640	59.125	78.182	101.128	101.128	101.128
	ST-26	JOINT INFRASTRUCTURE PROTECTION PROGRAM	0.000	69.900	0.000	0.000	0.000	0.000	0.000	0.000
	62301E	COMPUTING SYS & COMM TECHNOLOGY	294.398	417.723	328.602	334.676	353.735	391.548	398.548	395.348
62383E	BW-01	BIOLOGICAL WARFARE DEFENSE	58.452	88.000	148.500	151.000	151.500	135.800	116.800	113.800
62702E	TT-03	NAVAL WARFARE TECHNOLOGY	17.957	15.596	14.053	14.172	27.172	27.172	27.172	27.172
	TT-04	ADVANCED LAND SYSTEMS TECHNOLOGY	20.330	47.700	45.750	46.686	55.686	60.886	60.886	60.886
	TT-05	ADVANCED TARGETING TECHNOLOGY	0.000	0.000	0.000	0.000	10.000	38.300	48.300	58.300
	TT-06	ADVANCED TACTICAL TECHNOLOGY	53.100	60.034	23.267	25.728	31.800	48.728	48.728	48.728
	TT-07	AERONAUTICS TECHNOLOGY	19.135	34.000	36.000	44.011	45.000	45.648	51.648	55.648
	TT-10	ADVANCED LOGISTICS TECHNOLOGY	20.685	21.665	10.633	10.000	20.000	20.000	20.000	20.000
	TT-11	JOINT LOGISTICS ACTD	9.790	10.000	10.000	10.000	10.000	0.000	0.000	0.000
	62702E	TACTICAL TECHNOLOGY	140.997	188.995	139.703	150.597	199.658	240.734	256.734	270.734
62708E	IC-03	INTERGRADED COMMAND & CONTROL TECH	43.994	34.000	32.000	32.000	0.000	0.000	0.000	0.000
62712E	MPT-01	MATERIALS PROCESSING TECHNOLOGY	123.481	148.590	136.066	169.827	169.780	164.227	169.227	179.227
	MPT-02	MICROELECTRONIC DEVICE TECHNOLOGIES	60.984	84.701	86.722	87.881	77.426	80.413	90.413	100.413
	MPT-06	CRYOGENIC ELECTRONICS	17.608	8.203	11.546	12.000	15.000	16.000	16.000	16.000
	MPT-07	MILITARY MEDICAL/TRAUMA CARE TECHNOLOGY	11.285	2.914	0.000	0.000	0.000	0.000	0.000	0.000
	62712E	MATERIALS & ELECTRONICS TECHNOLOGY	213.358	244.408	234.334	269.708	262.206	260.640	275.640	295.640
63285E	ASP-01	ADVANCED AEROSPACE SYSTEMS	0.000	0.000	20.000	19.000	23.000	5.000	5.986	9.986

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**  
**RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSEWIDE**  
**PE/PROJECT LEVEL SUMMARY REPORT**  
(\$ in millions)

PE	PROJ	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
63739E	MT-03	UNCOOLED INTEGRATED SENSORS	8.289	11.000	3.000	0.000	0.000	0.000	0.000	0.000
	MT-04	ELECTRONIC MODULE TECHNOLOGY	66.732	68.892	61.142	47.395	53.999	81.363	84.925	86.925
	MT-05	TACTICAL INFORMATION SYSTEMS	28.328	36.596	19.640	22.748	21.100	0.000	0.000	0.000
	MT-06	MICROWAVE & ANALOG FRONT END TECHNOLOGY	17.543	4.000	0.000	0.000	0.000	0.000	0.000	0.000
	MT-07	CENTERS OF EXCELLENCE	4.844	4.000	0.000	0.000	0.000	0.000	0.000	0.000
	MT-08	MANUFACTURING TECHNOLOGY APPLICATIONS	26.175	22.200	20.253	0.000	0.000	0.000	0.000	0.000
	MT-10	ADVANCED LITHOGRAPHY	49.710	26.500	28.000	24.000	27.500	24.754	24.754	24.754
	MT-12	MEMS	70.555	71.549	78.979	80.000	79.000	88.300	96.300	93.300
	MT-15	MIXED TECHNOLOGY INTEGRATION	0.000	0.000	36.000	71.205	53.510	50.000	50.000	50.000
	63739E	ADVANCED ELECTRONICS TECHNOLOGY	272.176	244.737	247.014	245.348	235.109	244.417	255.979	254.979
63746E	MR-01	MARITIME TECHNOLOGY	32.750	15.000	0.000	0.000	0.000	0.000	0.000	0.000
63747E	EV-01	ELECTRIC VEHICLES	15.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63757E	CO-01	COOPERATIVE AGREEMENT PROGRAM	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63760E	CCC-01	COMMAND & CONTROL INFORMATION SYSTEMS	65.219	88.700	105.446	104.534	96.734	98.034	107.034	108.034
	CCC-02	INFORMATION INTEGRATION SYSTEMS	82.306	111.400	123.640	108.544	117.849	110.549	118.549	117.549
	63760E	COMMAND, CONT'L & COMMUNICATION SYS	147.525	200.100	229.086	213.078	214.583	208.583	225.583	225.583
63761E	CST-01	ADVANCED SIMULATION	29.050	26.698	0.000	0.000	0.000	0.000	0.000	0.000
	CST-02	GLOBAL GRID COMMUNICATIONS	38.519	27.916	5.250	0.000	0.000	0.000	0.000	0.000
	CST-03	DEFENSE SIMULATION INTERNET (DSI)	2.596	1.500	0.000	0.000	0.000	0.000	0.000	0.000
	63761E	COMMUNICATION & SIMULATION TECH	70.165	56.114	5.250	0.000	0.000	0.000	0.000	0.000
63762E	SGT-01	GUIDANCE TECHNOLOGY	35.286	33.600	26.766	22.731	22.633	35.764	36.764	39.764
	SGT-02	AEROSPACE SURVEILLANCE TECHNOLOGIES	19.987	68.855	73.511	72.729	73.517	93.486	80.500	87.500
	SGT-03	AIR DEFENSE INITIATIVE	20.170	33.500	40.350	30.680	35.460	35.000	38.000	38.200
	SGT-04	SENSORS & EXPLOITATION SYSTEMS	85.438	77.199	80.570	87.753	96.476	92.832	92.832	92.832
	63762E	SENSOR & GUIDANCE TECHNOLOGY	160.881	213.154	221.197	213.893	228.086	257.082	248.096	258.296
63763E	MRN-02	MARINE TECHNOLOGY	19.597	24.788	36.998	43.464	48.396	58.696	60.696	63.696

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**  
**RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSEWIDE**  
**PE/PROJECT LEVEL SUMMARY REPORT**  
(\$ in millions)

PE	PROJ	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
63764E	LNW-01	RAPID STRIKE FORCE TECHNOLOGY		56.593	51.000	50.176	80.000	27.000	22.000	22.000
	LNW-02	SMALL UNIT OPERATIONS	40.304 39.015	51.897	53.413	56.200	48.500	60.000	65.000	65.000
	63764E	LAND WARFARE TECHNOLOGY	79.319	108.490	104.413	106.376	128.500	87.000	87.000	87.000
63765E	CLP-01	CLASSIFIED	124.194	55.500	38.500	20.200	10.000	0.000	0.000	0.000
63800E	JA-01	JOINT STRIKE FIGHTER PROGRAM	21.134	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63805E	GC-01	DUAL USE APPLICATIONS PROGRAMS	115.784	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65114E	BL-01	BLACKLITE	4.522	5.000	5.000	5.000	5.000	5.000	5.000	5.000
65502E	SB-01	SMALL BUSINESS	45.869	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65998E	MH-01	MANAGEMENT HEADQUARTERS (R&D)	35.515	38.611	40.603	42.024	43.541	45.164	46.602	46.602
99999E	CA-01	CANCELLED ACCOUNTS	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AGENCY TOTAL		2,001.389	2,039.722	1,936.600	1,916.400	1,974.500	2,016.600	2,062.600	2,109.600
BA-01	TOTAL		66.693	65.102	65.400	70.036	71.186	76.936	79.936	82.936
BA-02	TOTAL		790.227	1,013.126	923.139	937.981	967.099	1,028.722	1,047.722	1,075.522
BA-03	TOTAL		1,058.530	917.883	902.458	861.359	887.674	860.778	883.340	899.540
BA-06	TOTAL		85.939	43.611	45.603	47.024	48.541	50.164	51.602	51.602
	AGENCY TOTAL		2,001.389	2,039.722	1,936.600	1,916.400	1,974.500	2,016.600	2,062.600	2,109.600

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**  
**RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSEWIDE**  
**PE/PROJECT LEVEL SUMMARY REPORT**  
(\$ in millions)

PE	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
61101E	DEFENSE RESEARCH SCIENCES								
	PB	68.332	65.102	65.400	70.036	71.186	76.936	0.000	0.000
	BES	66.693	65.102	65.400	70.036	71.186	76.936	79.936	82.936
	Delta	-1.639	0.000	0.000	0.000	0.000	0.000	79.936	82.936
62110E	NEXT GENERATION INTERNET								
	PB	40.453	40.000	40.000	0.000	0.000	0.000	0.000	0.000
	BES	39.028	40.000	40.000	0.000	0.000	0.000	0.000	0.000
	Delta	-1.425	0.000	0.000	0.000	0.000	0.000	0.000	0.000
62301E	COMPUTING SYS & COMM TECHNOLOGY								
	PB	309.037	417.723	368.779	412.248	436.840	446.548	0.000	0.000
	BES	294.398	417.723	328.602	334.676	353.735	391.548	398.548	395.348
	Delta	-14.639	0.000	-40.177	-77.572	-83.105	-55.000	398.548	395.348
62383E	BIOLOGICAL WARFARE DEFENSE								
	PB	60.805	88.000	77.300	74.000	77.848	75.800	0.000	0.000
	BES	58.452	88.000	148.500	151.000	151.500	135.800	116.800	113.800
	Delta	-2.353	0.000	71.200	77.000	73.652	60.000	116.800	113.800
62702E	TACTICAL TECHNOLOGY								
	PB	148.331	188.995	186.619	212.597	224.586	242.434	0.000	0.000
	BES	140.997	188.995	139.703	150.597	199.658	240.734	256.734	270.734
	Delta	-7.334	0.000	-46.916	-62.000	-24.928	-1.700	256.734	270.734
62708E	INTERGRATED COMMAND & CONTROL TECH								
	PB	45.695	34.000	32.000	32.000	0.000	0.000	0.000	0.000
	BES	43.994	34.000	32.000	32.000	0.000	0.000	0.000	0.000
	Delta	-1.701	0.000	0.000	0.000	0.000	0.000	0.000	0.000
62712E	MATERIALS & ELECTRONICS TECHNOLOGY								
	PB	231.353	244.408	234.218	250.208	264.706	266.640	0.000	0.000
	BES	213.358	244.408	234.334	269.708	262.206	260.640	275.640	295.640
	Delta	-17.995	0.000	0.116	19.500	-2.500	-6.000	275.640	295.640
63285E	ADVANCED AEROSPACE SYSTEMS								
	PB	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	BES	0.000	0.000	20.000	19.000	23.000	5.000	5.986	9.986
	Delta	0.000	0.000	20.000	19.000	23.000	5.000	5.986	9.986
63739E	ADVANCED ELECTRONICS TECHNOLOGY								
	PB	281.909	244.737	259.014	212.385	233.340	241.279	0.000	0.000
	BES	272.176	244.737	247.014	245.348	235.109	244.417	255.979	254.979
	Delta	-9.733	0.000	-12.000	32.963	1.769	3.138	255.979	254.979

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**  
**RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSEWIDE**  
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(\$ in millions)

PE	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
63746E	MARITIME TECHNOLOGY								
	PB	36.030	15.000	0.000	0.000	0.000	0.000	0.000	0.000
	BES	32.750	15.000	0.000	0.000	0.000	0.000	0.000	0.000
	Delta	-3.280	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63747E	ELECTRIC VEHICLES								
	PB	14.522	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	BES	15.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Delta	0.478	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63757E	COOPERATIVE AGREEMENT								
	PB	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	BES	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Delta	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63760E	COMMAND, CONT'L & COMMUNICATION SYS								
	PB	150.010	200.100	187.369	206.234	212.034	211.034	0.000	0.000
	BES	147.525	200.100	229.086	213.078	214.583	208.583	225.583	225.583
	Delta	-2.485	0.000	41.717	6.844	2.549	-2.451	225.583	225.583
63761E	COMMUNICATION & SIMULATION TECH								
	PB	74.212	56.114	29.750	31.049	32.549	36.549	0.000	0.000
	BES	70.165	56.114	5.250	0.000	0.000	0.000	0.000	0.000
	Delta	-4.047	0.000	-24.500	-31.049	-32.549	-36.549	0.000	0.000
63762E	SENSOR & GUIDANCE TECHNOLOGY								
	PB	167.184	213.154	232.646	204.718	189.169	212.096	0.000	0.000
	BES	160.881	213.154	221.197	213.893	228.086	257.082	248.096	258.296
	Delta	-6.303	0.000	-11.449	9.175	38.917	44.986	248.096	258.296
63763E	MARINE TECHNOLOGY								
	PB	19.626	24.788	33.998	43.464	59.196	68.696	0.000	0.000
	BES	19.597	24.788	36.998	43.464	48.396	58.696	60.696	63.696
	Delta	-0.029	0.000	3.000	0.000	-10.800	-10.000	60.696	63.696
63764E	LAND WARFARE TECHNOLOGY								
	PB	80.924	108.490	93.413	89.700	101.500	87.000	0.000	0.000
	BES	79.319	108.490	104.413	106.376	128.500	87.000	87.000	87.000
	Delta	-1.605	0.000	11.000	16.676	27.000	0.000	87.000	87.000
63765E	CLASSIFIED DARPA PROGRAMS								
	PB	129.411	55.500	48.500	29.000	21.200	0.000	0.000	0.000
	BES	124.194	55.500	38.500	20.200	10.000	0.000	0.000	0.000
	Delta	-5.217	0.000	-10.000	-8.800	-11.200	0.000	0.000	0.000

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**  
**RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSEWIDE**  
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(\$ in millions)

PE	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
63800E	JOINT STRIKE FIGHTER PROGRAM								
	PB	23.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	BES	21.134	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Delta	-1.885	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63805E	DUAL USE APPLICATIONS PROGRAM								
	PB	120.395	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	BES	115.784	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Delta	-4.611	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65114E	BLACKLITE								
	PB	4.532	5.000	5.000	5.000	5.000	5.000	5.000	5.000
	BES	4.522	5.000	5.000	5.000	5.000	5.000	5.000	5.000
	Delta	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65502E	SMALL BUSINESS INNOVATIVE RESEARCH								
	PB	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	BES	45.869	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Delta	45.869	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65898E	MANAGEMENT HEADQUARTERS								
	PB	35.039	38.611	42.603	43.782	45.310	46.602	46.602	46.602
	BES	35.515	38.611	40.603	42.024	43.541	45.164	46.602	46.602
	Delta	0.476	0.000	-2.000	-1.758	-1.769	-1.438	46.602	46.602
99999E	CANCELLED ACCOUNTS								
	PB	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	BES	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Delta	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	TOTAL Presidents Budget	2,040.819	2,039.722	1,936.609	1,916.421	1,974.464	2,016.614	0.000	0.000
	TOTAL BES	2,001.389	2,039.722	1,936.600	1,916.400	1,974.500	2,016.600	2,062.600	2,109.600
	DELTA	-39.430	0.000	-0.009	-0.021	0.036	-0.014	2,062.600	2,109.600

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY  
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSEWIDE  
PE/PROJECT LEVEL SUMMARY REPORT  
(\$ in millions)**

PE	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
BA-01	PB	68.332	65.102	65.400	70.036	71.186	76.936	0.000	0.000
	BES	66.693	65.102	65.400	70.036	71.186	76.936	79.936	82.936
	<b>Delta</b>	-1.639	0.000	0.000	0.000	0.000	0.000	79.936	82.936
BA-02	PB	835.674	1,013.126	938.916	981.053	1,003.980	1,031.422	0.000	0.000
	BES	790.227	1,013.126	923.139	937.981	967.099	1,028.722	1,047.722	1,075.522
	<b>Delta</b>	-45.447	0.000	-15.777	-43.072	-36.881	-2.700	1,047.722	1,075.522
BA-03	PB	1,097.242	917.883	884.690	816.550	848.988	856.654	0.000	0.000
	BES	1,058.530	917.883	902.458	861.359	887.674	860.778	883.340	899.540
	<b>Delta</b>	-38.712	0.000	17.768	44.809	38.686	4.124	883.340	899.540
BA-06	PB	39.571	43.611	47.603	48.782	50.310	51.602	0.000	0.000
	BES	85.939	43.611	45.603	47.024	48.541	50.164	51.602	51.602
	<b>Delta</b>	46.368	0.000	-2.000	-1.758	-1.769	-1.438	51.602	51.602
TOTAL Presidents Budget		2,040.819	2,039.722	1,936.609	1,916.421	1,974.464	2,016.614	0.000	0.000
TOTAL BES		2,001.389	2,039.722	1,936.600	1,916.400	1,974.500	2,016.600	2,062.600	2,109.600
<b>DELTA</b>		-39.430	0.000	-0.009	-0.021	0.036	-0.014	2,062.600	2,109.600



## Program Element Comparison Summary

### Comparison of FY 1998 and 1999 Data:

A comparison of budget data from this R-1 to the February 1998 R-1 supporting the FY 1999 President's Budget submission is submitted in budget exhibit R-1C. The FY 1999 column does not reflect the August 11, 1998 PDM increase for Biological Warfare Defense. This will be accomplished by OSD Comptroller in a Program Budget Decision.

### Relationship of FY 2000/2001 Budget Structure to the FY 1999 Budget approved by Congress.

#### Budget Activity 3

0603285E Advanced Aerospace Systems

DARPA established this new PE as part of the May 1998 POM submission. This PE was created to support new aerospace programs in DARPA's Advanced Technology Development budget activity. Beginning in FY 2000, programs within this PE will be developing critical enabling technologies applicable to both manned and unmanned aerospace systems that address near-term and far-term military needs. Programs in the FY 2000 request are continuations of unmanned air vehicle programs initiated in FY 1998 under Budget Activity 2 (PE 0602702E, Tactical Technology) that will demonstrate vertical take-off and landing concepts and the initiation of a supersonic low cost cruise missile interceptor and advanced space transportation and robotic orbiter programs.

Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

September 1998

Budget Plan

Identification code: 97-0400-DE	Estimate FY 1998	Estimate FY 1999	Estimate FY 2000	Estimate FY 2001
Program by activities:				
Direct Program:				
01.000 Basic Research	66,693	65,102	65,400	70,036
02.000 Applied Research	790,227	1,013,126	923,139	937,981
03.000 Advanced Technology Development	1,058,530	917,883	902,458	861,359
06.000 Management Support	85,939	43,611	45,603	47,024
Total Direct Program	2,001,389	2,039,722	1,936,600	1,916,400
R01.000 Reimbursable Program:				
Total Program	22,300	40,000	40,000	40,000
	2,023,689	2,079,722	1,976,600	1,956,400
Financing:				
F14.010 New Non-Federal Sources	-5			
F11.010 New Federal Funds (-)	-22,300	-40,000	-40,000	-40,000
Total Budget Authority	2,001,384	2,039,722	1,936,600	1,916,400
Budget authority:				
F40.010 Appropriation EN/EST	2,111,067	2,039,722	1,936,600	1,916,400
F40.760 Reduction Pursuant to PL 105-56, 8035	-5,919			
F40.761 Reduction Pursuant to PL 105-56, 8041	-5,255			
F40.762 Reduction Pursuant to PL 105-56, 8043	-31,666			
F40.763 Reduction Pursuant to PL 105-56, 8048	-26,408			
F41.000 Transferred to Other Accounts	-40,993			
F42.000 Transferred from Other Accounts	558			
Total Budget Authority	2,001,384	2,039,722	1,936,600	1,916,400

Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

September 1998

Budget Plan

Estimate  
 FY 1998

Identification code: 97-0400-DE

Program by activities:

Direct Program:

01.000  
 02.000  
 03.000  
 06.000

Basic Research  
 Applied Research  
 Advanced Technology Development  
 Management Support  
 Total Direct Program

66,693  
 790,227  
 1,058,530  
 85,939  
 2,001,389

R01.000

Reimbursable Program:

Total Program

17,000  
 2,018,389

Financing:

F14.010  
 F11.010

New Non-Federal Sources  
 New Federal Funds (-)  
 Total Budget Authority

-5  
 -17,000  
 2,001,384

Budget authority:

F40.010  
 F40.760  
 F40.761  
 F40.762  
 F40.763  
 F41.000  
 F42.000

Appropriation EN/EST  
 Reduction Pursuant to PL 105-56, 8035  
 Reduction Pursuant to PL 105-56, 8041  
 Reduction Pursuant to PL 105-56, 8043  
 Reduction Pursuant to PL 105-56, 8048  
 Transferred to Other Accounts  
 Transferred from Other Accounts  
 Total Budget Authority

2,111,067  
 -5,919  
 -5,255  
 -31,666  
 -26,408  
 -40,993  
 558  
 2,001,384

Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

		Budget Plan
Identification code: 97-0400-DE		Estimate FY 1999
Program by activities:		
Direct Program:		
01.000	Basic Research	65,102
02.000	Applied Research	1,013,126
03.000	Advanced Technology Development	917,883
06.000	Management Support	43,611
	Total Direct Program	2,039,722
R01.000	Reimbursable Program:	40,000
	Total Program	2,079,722
F11.010	Financing:	
	New Federal Funds (-)	-40,000
	Total Budget Authority	<u>2,039,722</u>
F40.010	Budget authority:	
	Appropriation EN/EST	<u>2,039,722</u>
	Total Budget Authority	2,039,722

Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

Budget Plan

Estimate  
FY 2000

Identification code: 97-0400-DE

Program by activities:

Direct Program:

01.000	Basic Research	65,400
02.000	Applied Research	923,139
03.000	Advanced Technology Development	902,458
06.000	Management Support	<u>45,603</u>
	Total Direct Program	1,936,600

R01.000	Reimbursable Program:	<u>40,000</u>
	Total Program	1,976,600

F11.010	Financing:	
	New Federal Funds (-)	<u>-40,000</u>
	Total Budget Authority	<u>1,936,600</u>

F40.010	Budget authority:	
	Appropriation EN/EST	<u>1,936,600</u>
	Total Budget Authority	1,936,600

Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

Budget Plan

Estimate  
FY 2001

Identification code: 97-0400-DE

Program by activities:

Direct Program:

01.000	Basic Research	70,036
02.000	Applied Research	937,981
03.000	Advanced Technology Development	861,359
06.000	Management Support	47,024
	Total Direct Program	1,916,400

R01.000 Reimbursable Program:

Total Program

40,000  
1,956,400

Financing:

F11.010 New Federal Funds (-)  
Total Budget Authority

-40,000  
1,916,400

Budget authority:

F40.010 Appropriation EN/EST

1,916,400

Total Budget Authority

1,916,400

Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

September 1998

Obligation Plan

Identification code: 97-0400-DE		Estimate FY 1998	Estimate FY 1999	Estimate FY 2000	Estimate FY 2001
Program by activities:					
Direct Program:					
01.000	Basic Research	71,241	64,007	65,355	69,341
02.000	Applied Research	733,803	963,887	936,637	935,755
03.000	Advanced Technology Development	1,054,387	917,809	904,771	867,524
06.000	Management Support	93,407	48,241	45,304	46,811
	Total Direct Obligations	1,952,839	1,993,944	1,952,068	1,919,430
R01.000	Reimbursable Obligations	22,300	40,000	40,000	40,000
	Total Obligations	1,975,139	2,033,944	1,992,068	1,959,430
Financing:					
Offsetting collections from:					
F14.010	New Non-Federal Sources	-5			
F11.010	New Federal Funds (-)	-22,300	-40,000	-40,000	-40,000
F21.020	Unobligated balance available, start of year: For completion of prior year budget plans	-211,630	-260,181	-305,958	-290,490
F24.020	Unobligated balance available, end of year: For completion of prior year budget plans	260,181	305,958	290,490	287,460
	Total Budget Authority	2,001,384	2,039,722	1,936,600	1,916,400
Budget Authority:					
F40.010	Appropriation EN/EST	2,111,067	2,039,722	1,936,600	1,916,400
F40.760	Reduction Pursuant to PL 105-56, 8035	-5,919			
F40.761	Reduction Pursuant to PL 105-56, 8041	-5,255			
F40.762	Reduction Pursuant to PL 105-56, 8043	-31,666			
F40.763	Reduction Pursuant to PL 105-56, 8048	-26,408			
F41.000	Transferred to Other Accounts	-40,993			
F42.000	Transferred from Other Accounts	558			
	Total Budget Authority	2,001,384	2,039,722	1,936,600	1,916,400

Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

September 1998

		Obligations
Identification code: 97-0400-DE		Fiscal Year 1997 Funds
Program by activities:		FY 1998 Estimate
Direct Program:		
01.000	Basic Research	13,218
02.000	Applied Research	46,306
03.000	Advanced Technology Development	133,466
06.000	Management Support	<u>18,640</u>
Total Direct Obligations		211,630
Total Obligations		211,630
Financing:		
F21.020	Unobligated balance available, start of year: For completion of prior year budget plans	<u>-216,155</u>
Total Budget Authority		-4,525
F40.600	Contingent Emergency Appropriation not avail for obligation	-4,000
F41.000	Transferred to other accounts	<u>-525</u>
Total Budget Authority		-4,525



Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

September 1998

		Obligations	
		Fiscal Year 1998 Funds	FY 1999 Estimate
Identification code: 97-0400-DE		FY 1998 Estimate	FY 1999 Estimate
Program by activities:			
Direct Program:			
01.000	Basic Research	58,023	8,670
02.000	Applied Research	687,497	102,730
03.000	Advanced Technology Development	920,921	137,609
06.000	Management Support	74,767	11,172
	Total Direct Obligations	1,741,209	260,181
R01.000	Reimbursable Obligations	22,300	
	Total Obligations	1,763,509	260,181
Financing:			
Offsetting collections from:			
F11.010	New Federal Funds	-22,300	
F14.010	New Non-Federal Funds	-5	
F21.020	Unobligated balance available, start of year: For completion of prior year budget plans		-260,181
F24.020	Unobligated balance available, end of year: For completion of prior year budget plans	260,181	
	Total Budget Authority	2,001,384	0
F40.010	Appropriation EN/EST	2,111,067	
F40.760	Reduction Pursuant to PL 105-56, 8035	-5,919	
F40.761	Reduction Pursuant to PL 105-56, 8041	-5,255	
F40.762	Reduction Pursuant to PL 105-56, 8043	-31,666	
F40.763	Reduction Pursuant to PL 105-56, 8048	-26,408	
F41.000	Transferred to Other Accounts	-40,993	
F42.000	Transferred from Other Accounts	558	
	Total Budget Authority	2,001,384	

Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

September 1998

		Fiscal Year 1999 Funds	
Identification code: 97-0400-DE		FY 1999 Estimate	FY 2000 Estimate
		Obligations	
Program by activities:			
Direct Program:			
01.000	Basic Research	55,337	9,765
02.000	Applied Research	861,157	151,969
03.000	Advanced Technology Development	780,201	137,682
06.000	Management Support	37,069	6,542
	Total Direct Obligations	1,733,764	305,958
R01.000	Reimbursable Obligations	40,000	
	Total Obligations	1,773,764	305,958
Financing:			
Offsetting collections from:			
F11.010	New Federal Funds	-40,000	
F21.020	Unobligated balance available, start of year: For completion of prior year budget plans		-305,958
F24.020	Unobligated balance available, end of year: For completion of prior year budget plans	305,958	
	Total Budget Authority	2,039,722	0
F40.010	Appropriation EN/EST	2,039,722	
	Total Budget Authority	2,039,722	

Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

September 1998

		Obligations	
Identification code: 97-0400-DE		Fiscal Year 2000 Funds	
		FY 2000 Estimate	FY 2001 Estimate
Program by activities:			
Direct Program:			
01.000	Basic Research	55,590	9,810
02.000	Applied Research	784,668	138,471
03.000	Advanced Technology Development	767,089	135,369
06.000	Management Support	<u>38,763</u>	<u>6,840</u>
	Total Direct Obligations	1,646,110	290,490
R01.000	Reimbursable Obligations	<u>40,000</u>	
	Total Obligations	1,686,110	290,490
Financing:			
F11.010	Offsetting collections from: New Federal Funds	-40,000	
F21.020	Unobligated balance available, start of year: For completion of prior year budget plans		-290,490
F24.020	Unobligated balance available, end of year: For completion of prior year budget plans	<u>290,490</u>	
	Total Budget Authority	1,936,600	0
F40.010	Appropriation EN/EST	<u>1,936,600</u>	
	Total Budget Authority	1,936,600	

Research, Development Test and Evaluation, Defensewide  
 Defense Advanced Research Projects Agency  
 Program and Financing  
 (Dollars in Thousands)

September 1998

		Fiscal Year 2001 Funds	
		FY 2001 Estimate	FY 2002 Estimate
		Obligations	
Identification code: 97-0400-DE			
Program by activities:			
Direct Program:			
01.000	Basic Research	59,531	10,505
02.000	Applied Research	797,284	140,697
03.000	Advanced Technology Development	732,155	129,204
06.000	Management Support	39,970	7,054
	Total Direct Obligations	1,628,940	287,460
R01.000	Reimbursable Obligations	40,000	
	Total Obligations	1,668,940	287,460
Financing:			
Offsetting collections from:			
F11.010	New Federal Funds	-40,000	
F21.020	Unobligated balance available, start of year: For completion of prior year budget plans		-287,460
F24.020	Unobligated balance available, end of year: For completion of prior year budget plans	287,460	
	Total Budget Authority	1,916,400	0
F40.010	Appropriation EN/EST	1,916,400	
	Total Budget Authority	1,916,400	

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY  
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE  
OBJECT CLASSIFICATION  
(\$ THOUSANDS)

<u>Personnel Compensation</u>	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate
11.1 Full-Time Permanent	9,768	10,647	9,697	9,682
11.3 Other Than Full-Time Permanent	643	663	683	705
11.5 Other Personnel Compensation	715	785	576	599
11.8 Special Personnel Services Payments	7,690	10,962	13,182	13,826
Total Personnel Compensation	18,816	23,057	24,138	24,812
<u>Direct Obligations</u>				
11.9 Total Personnel Compensation	18,816	23,057	24,138	24,812
12.0 Civilian Personnel Benefits	2,009	2,161	2,076	2,078
13.0 Benefits for Former Personnel	175	0	0	0
21.0 Travel and Transportation of Persons	3,000	3,100	3,153	3,207
23.1 Rental Payments to GSA	2,119	2,153	2,190	2,227
23.2 Rental Payments to Others	160	163	165	168
23.3 Communications, Utilities and Miscellaneous Charges	867	881	896	911
24.0 Printing and Reproduction	26	26	27	27
25.1 Advisory & Assistance Services	61,520	55,400	54,500	53,600
25.2 Other Services	4,948	5,027	5,113	5,200
25.5 R&D Contracts	1,856,265	1,898,458	1,856,116	1,823,326
26.0 Supplies and Materials	558	567	577	587
31.0 Equipment	2,376	2,951	3,117	3,287
Total Direct Obligations	1,952,839	1,993,944	1,952,068	1,919,430
<u>Reimbursable Obligations</u>				
25.5 R&D Contracts	22,300	40,000	40,000	40,000
Total Obligations	1,975,139	2,033,944	1,992,068	1,959,430

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY  
FY 2000/2001 DEFENSE BUDGET REVIEW  
SCHEDULE OF CIVILIAN AND MILITARY PERSONNEL**

	<u>FY 1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>	<u>FY 2003</u>	<u>FY 2004</u>	<u>FY 2005</u>
<b>I. CIVILIAN PERSONNEL (FTE)</b>								
RDT&E Defensewide								
US Direct Hire	134	139	123	119	119	119	119	119
Intergovernmental								
Personnel Act (IPA)	50	68	78	78	78	78	78	78
Total, RDT&E	184	207	201	197	197	197	197	197
<b>II. ACTIVE MILITARY PERSONNEL (ES)</b>								
Officer, Army	3	3	3	3	3	3	3	3
Officer, Navy	4	3	3	3	3	3	3	3
Officer, Air Force	11	11	11	11	11	11	11	11
Enlisted, Air Force	1	1	1	1	1	1	1	1
Total Air Force	12	12	12	12	12	12	12	12
Total Military	19	18	18	18	18	18	18	18
TOTAL	203	225	219	215	215	215	215	215

Exhibit PB-4  
September, 1998

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## **SECTION II**

# **MODERNIZATION AND INVESTMENT**



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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost	
Total Program Element (PE) Cost	66,693	65,102	65,400	70,036	71,186	76,936	79,936	82,936	Continuing	Continuing	
Information Sciences CCS-02	16,376	18,899	20,100	19,500	19,700	19,700	20,700	21,700	Continuing	Continuing	
Electronic Sciences ES-01	36,192	20,512	22,910	30,583	30,433	36,183	37,183	38,183	Continuing	Continuing	
Materials Sciences MS-01	14,125	25,691	22,390	19,953	21,053	21,053	22,053	23,053	Continuing	Continuing	

(U) Mission Description:

- (U) The Defense Research Sciences Program element is budgeted in the Basic Research Budget Activity because it provides the technical foundation for long-term improvements through the discovery of new phenomena and the exploration of the potential of such phenomena for national security applications. It supports the scientific study and experimentation that is the basis for more advanced knowledge and understanding in information, electronic and materials sciences.
- (U) The Information Sciences project supports basic scientific study and experimentation in information sciences technology areas such as computational models, Quantum Computing, biological computing and human-language systems.
- (U) The Electronic Sciences project explores and demonstrates electronic and optoelectronic devices, circuits and processing concepts that will provide: (1) new technical options for meeting the information gathering, transmission and processing required to maintain near-real time knowledge of the enemy, and the ability to communicate decisions based on that knowledge to all forces in near-real time; and (2) a substantial increase in performance and cost reduction of military systems providing these capabilities.
- (U) The Materials Sciences project is concerned with the development of: high power density/high energy density mobile and portable power sources; processing and design approaches for nanoscale and/or biomolecular materials and interfaces; medical pathogen countermeasures; materials and measurements for molecular-scale electronics; and advanced thermoelectric materials for cooling and power generation.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E	September 1998

(U)	<u>Program Change Summary: (In Millions)</u>	<u>FY1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>
	Previous President's Budget	68.332	65.102	65.400	70.036
	Current Budget	66.693	65.102	65.400	70.036

(U) Change Summary Explanation:

FY 1998      Decrease reflects SBIR reprogramming and minor realignment of program priorities.

UNCLASSIFIED

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE		September 1998		
APPROPRIATION/BUDGET ACTIVITY				R-1 ITEM NOMENCLATURE							
RDT&E, Defense-wide BA I Basic Research				Defense Research Sciences PE 0601101E, Project CCS-02							
COST (In Thousands)		FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Information Sciences CCS-02		16,376	18,899	20,100	19,500	19,700	19,700	20,700	21,700	Continuing	Continuing

(U) Mission Description:

(U) This project supports scientific study and experimentation that is the basis for more advanced knowledge and understanding in information sciences technology areas related to long-term national security requirements such as computational models and new mechanisms for performing computation and communication involving quantum physics, biological and optical processes. This project is also exploring innovative approaches to the composition of software and novel human computer interface technologies.

(U) In the area of quantum computing, the project will identify and probe new classes of computing technologies which may offer spectacular performance/cost/size/weight/power improvements beyond the ultimate limitations of today's semiconductor-based computing. Quantum logic, based on subatomic scale physical phenomena, could enable a tremendous leap in computational capacity. However, a number of significant hurdles, including the development of sequencing mechanisms, large scale storage, input/output channels and quantum-enabled approaches to algorithms and error correction must be overcome.

(U) In the area of biological computing, the project will support the scientific study and experimentation that is at the interface of information technology and biological technology, with emphasis on biological software, computation based on biological materials, physical interfaces between electronics and biology, and interactive biology. It will also apply information technology to accelerate the analysis and synthesis of biological processes. The seamless integration of information technology and biological processes will provide the ability to exert computational control over biological and chemical processes.

(U) In the area of optical communication and computing, the project will explore new approaches to transmission based on solitons and identify novel buffering technologies that can be substituted for optical delay lines.

(U) In the areas of software engineering, the project will investigate approaches to "programming in the large" that leverage the availability of large numbers of computational elements.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BAI Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02	September 1998

- (U) In the area of human computer interfaces the project will study interface technologies and their relationship to cognitive processes.
- (U) Program Accomplishments and Plans:
- (U) FY1998 Accomplishments:
- Investigated computational models suitable for implementation using Quantum computing techniques. (\$ 5.681 Million)
  - Developed architecture for low-power configurable computational elements. (\$ 1.303 Million)
  - Prototyped robust spoken and text language technologies with emphasis on affordable grammars and understanding. (\$ 7.479 Million)
  - Evaluated quality of service specifications; demonstrated real-time adaptive control and resource management; released version of defense-critical software based on scalable library technology. (\$ 1.913 Million)
- (U) FY1999 Plans:
- Demonstrate and validate computing models, with emphasis on: DNA-based logic operations; cell-based computation and novel communication pathways; and the scalability of these techniques in defense applications. (\$ 12.200 Million)
  - Investigate novel control mechanisms for self-organizing and autonomous systems. (\$ 1.999 Million)
  - Demonstrate human-computer interaction for crisis planning and automatic transcription of conversational speech. (\$ 3.000 Million)
  - Validate low-power configurable architecture; develop supporting software; and demonstrate automated mapping of 500K elements. (\$ 1.700 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BAI Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02	September 1998

(U) **FY2000 Plans:**

- Biological Computing. (\$ 7.000 Million)
  - Evaluate alternative approaches to DNA-based computing and identify the most promising research opportunities for enhancement and acceleration.
  - Explore mechanisms for sequencing of DNA-based computations.
  - Investigate novel approaches to real-time biological instrumentation in support of interactive biology.
- Quantum Computing. (\$ 2.000 Million)
  - Develop new algorithms for quantum-enabled computation.
  - Design sequencing and input/output mechanisms for quantum computing.
- Optical Communication. (\$ 2.000 Million)
  - Identify alternative optical buffering technologies.
- Software Engineering. (\$ 4.600 Million)
  - Investigate use of declarative interfaces for tasking and querying of large distributed systems.
- Human Computer Interface. (\$ 4.500 Million)
  - Investigate relevance of new results in cognitive science research to spoken language and haptic interfaces.

(U) **FY2001 Plans:**

- Biological Computing. (\$ 5.900 Million)
  - Prototype demonstration of robot control sequencing of DNA-based computations.
  - Demonstrate real-time multi-sensor imaging of cell processes in support of interactive biology.
  - Investigate high speed synthesis of DNA segments of at least 100 base pairs.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BAI Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02	September 1998

- Quantum Computing. (\$ 2.000 Million)
  - Simulate new algorithms for quantum-enabled computation and evaluate potential speed-up over conventional methods.
  - Prototype demonstration of sequencing and input/output mechanisms enabling quantum computing.
- Optical Communication. (\$ 3.000 Million)
  - Laboratory demonstration of soliton-based packet multiplexing, incorporating optical buffering.
- Software Engineering. (\$ 4.600 Million)
  - Prototype demonstration using declarative interfaces for tasking and querying of large distributed systems.
- Human Computer Interface. (\$ 4.000 Million)
  - Investigate interface technologies to facilitate the tasking and management of autonomous systems.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide BAI Basic Research					Defense Research Sciences PE 0601101E, Project ES-01						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost	
Electronic Sciences ES-01	36,192	20,512	22,910	30,583	30,433	36,183	37,183	38,183	Continuing	Continuing	

(U) Mission Description:

(U) This project seeks to continue the phenomenal progress in microelectronics innovation that has characterized the last decades by exploring and demonstrating electronic and optoelectronic devices, circuits and processing concepts that will: 1) provide new technical options for meeting the information gathering, transmission and processing required to maintain near real-time knowledge of the enemy, and the ability to communicate decisions based on that knowledge to all forces in near real-time; and 2) provide new means for achieving substantial increases in performance and cost reduction of military systems providing these capabilities. Research areas include new electronic and optoelectronic device and circuit concepts, operation of devices at higher frequency and lower power, extension of diode laser operation to new wavelength ranges relevant to military missions, development of uncooled and novel infrared detector materials for night vision and other sensor applications, development of innovative optical and electronic technologies for interconnecting modules in high performance systems, research to realize field portable electronics with reduced power requirements, and research addressing affordability and reliability. Additionally, electronically controlled microinstruments offer the possibility of nm-scale probing, sensing and manipulation for ultra-high density information storage "on-a-chip", for nm-scale patterning, and for molecular level analysis and synthesis. These Microinstruments for nm-scale mechanical, electrical and fluidic analysis offer new approaches to integration, testing, controlling, manipulating and manufacturing nm-scale structures, molecules and devices.

(U) Program Accomplishments and Plans:(U) FY1998 Accomplishments:

- Optoelectronics - Demonstrated feasibility of using Gallium Nitride detectors as a UV solar-blind detector for missile threat warning and demonstrated UV/blue lasers operating continuous wave for high-density memory and chemical/biological detection. (\$ 9.200 Million)
- Infrared Detector Materials - Determined process for low temperature deposition of thin film uncooled materials. (\$ 2.600 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BAI Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01	September 1998

- UltraElectronics - Demonstrated feasibility of combining a resonant tunneling device (RTD) with conventional devices, silicon based quantum metal oxide semiconductor (MOS) technology, and simple quantum cellular automatic logic circuits using silicon and silicon germanium structures. (\$ 10.000 Million)
- UltraPhotonics - Demonstrated practical means for implementing high speed optical buffer memories and signal address recognition based on coherent, all-optical (photon-echo) technology. Demonstrated the utility of low cost silicon electronic devices doped with optically active elements (such as Erbium) for applications that were the exclusive domain of more expensive compound semiconductor devices or glassy materials. (\$ 9.000 Million)
- Low Power Electronics - Completed low-power electronics programs in the areas of circuit architecture and power management techniques. Demonstrated 256 x 256 pixel image sensor with on-chip, 10-bit Analog-Digital Converter. (\$ 5.392 Million)

(U) FY1999 Plans:

- Infrared Detector Materials - Establish feasibility of new uncooled detector structures, including micromachined arrays, thin film ferroelectrics and bolometric materials. (\$ 3.000 Million)
- UltraElectronics - Demonstrate programmable matched filter operating at gigahertz speed with substantially less power than silicon complimentary metal oxide semiconductor (Si CMOS), completely integrated molecular beam epitaxy (MBE) growth system that realizes closed-loop control of atomic layer growth and quantum device structures. (\$ 4.900 Million)
- UltraPhotonics - Identify the device properties limiting performance of vertical cavity lasers and demonstrate methods for controlling their output beam quality. (\$ 7.700 Million)
- Integrate promising new elements of ultraelectronics, high power electronics, non-volatile memory and Electro-Magnetic Interference (EMI) electronics. Address, evaluate, and apply current EMI thrusts in smaller, lighter, more mobile information systems and highest performance components and systems. (\$ 1.700 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01.	September 1998

- Initiate mechanical electronics development resulting in very high efficiency DC-DC converters. (\$ 1.000 Million)
  - Terahertz Technology - Explore technologies for a region of the electromagnetic spectrum (300Ghz to 10Thz, 1mm to 30 micrometer) that has previously been difficult to access using conventional technologies, in order to exploit opportunities in environmental sensing, upper-atmosphere imagery, and covert satellite communications. (\$ 2.212 Million)
- (U) **FY2000 Plans:**
- Mechanical Electronics - Demonstrate the properties for mechanical switches that include device speed and current density scale and size, hysteretic behavior for non-volatile memory applications, and reduce the threshold switching voltage to below 10V. (\$ 7.000 Million)
  - Terahertz Technology - Continue to exploit the terahertz region of the electromagnetic spectrum by investigating the best semiconductor approaches to sources and detectors, identifying mission critical operation, and feasibility to integrating these components to form a range of compact subsystems for applications in space based communications, remote sensing, collision avoidance radar, and covert communications. (\$ 8.600 Million)
  - Microinstruments - Demonstrate an integrated and mechanically positioned, nm-scale electrical probe array "on-a-chip" and demonstrate the recording of a 1GHz electrical signal on a 200nm<sup>2</sup> area. Demonstrate fluidic deposition and probing on a 20nm x 20nm area. Demonstrate an integrated microinstrument "on-a-chip" that reads an array of 1 billion, 5nm bits. Demonstrate the integrated robotic mechanisms "on-a-chip" for electromagnetic, electromechanical and microfluidic positioning, manipulation and transportation of nm-scale and micrometer-scale objects. Demonstrate molecular level synthesis of biochemical probes. (\$ 7.310 Million)

(U) **FY2001 Plans:**

- Terahertz Technology - Demonstrate for the terahertz spectral region the best semiconductor quantum well approaches to sources, demonstrate semiconductor quantum well detectors, and identify system requirements to achieve space communications, upper-atmosphere imagery, and close-operations covert communications. (\$ 13.800 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BAI Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01	September 1998

- Microinstruments - Demonstrate a patterning microinstrument that writes a pattern of array of 50nm minimum - feature-size (MFS) bits or pixels at a rate of  $6\text{cm}^2$  sec over an area of  $1\text{cm}^2$ . Demonstrate fluidic patterning of pixels  $20\text{nm} \times 20\text{nm}$  over a  $1\text{mm} \times 1\text{mm}$  area using a microinstrument "on-a-chip". Demonstrate an array of 10,000 probes for imaging 10nm defects, electrical pads or bits on an integrated circuit. Demonstrate non-destructive controlled manipulation of cells. (\$ 16.783 Million)

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide BA I Basic Research					Defense Research Sciences PE 0601101E, Project MS-01						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost	
Materials Sciences MS-01	14,125	25,691	22,390	19,953	21,053	21,053	22,053	23,053	Continuing	Continuing	

(U) Mission Description:

(U) This project is concerned with fundamental research leading to the development of high power density/high energy density mobile and portable power sources, advanced thermoelectric materials for cooling and power generation, processing and design approaches for nanoscale and/or biomolecular materials and interfaces, materials and measurements for molecular-scale electronics, and medical pathogen countermeasures.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Electrochemistry. (\$ 8.511 Million)
  - Constructed and tested a logistics fueled fuel cell power plant for mobile electric power applications.
  - Began component and system study/demonstration of a direct oxidation fuel cell for replacement of military standard batteries.
  - Explored alternative sources of energy for portable power applications (for example, piezoelectric materials).
  - Developed and demonstrated thermophotovoltaic materials with significantly improved performance.
- Nanoscale/Biomolecular Materials. (\$ 1.337 Million)
  - Exploited recent advances in materials design and processing to demonstrate nanostructural control of materials properties with an emphasis on emulating the complex microstructure and scale of biological materials.
- Pathogen Countermeasures. (\$ 2.477 Million)
  - Determined one or more mechanisms a stem cell could use to link the detection of a pathogen to the production by the cell of vaccines and/or therapeutics.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01	September 1998

- Thermoelectric Materials. (\$ 1.800 Million)
  - Demonstrated materials with a factor of two increase in the thermoelectric figure of merit.
- (U) **FY1999 Plans:**
  - Portable Power. (\$ 9.391 Million)
    - Optimize catalysts, polymeric membranes, and separator plates for high energy density fuel cell operation.
    - Brassboard testing of compact, high performance energy sources for portable power applications.
    - Demonstrate novel thermophotovoltaic power generation devices based on advanced materials.
  - Nanoscale/Biomolecular Materials. (\$ 6.300 Million)
    - Demonstrate the applicability of nanostructural and/or biomolecular materials in defense applications such as armor, high strength fibers, coatings, or electronics.
    - Develop single molecules and/or nanoparticles that exhibit electronic functionality and measure their intrinsic electronic properties.
  - Pathogen Countermeasures. (\$ 5.400 Million)
    - Determine mechanisms of disease causing (virulence) factors in pathogens of concern to the DoD.
  - Thermoelectric Materials. (\$ 4.600 Million)
    - Develop thin film cooler utilizing quantum well structures.
- (U) **FY2000 Plans:**
  - Portable Power. (\$ 5.000 Million)
    - Demonstrate, in the laboratory, integrated portable power systems that operate on logistics fuel.
    - Demonstrate the applicability of novel portable power systems for individual soldier applications.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BAI Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01	September 1998

- Nanoscale/Biomolecular Materials. (\$ 4.000 Million)
  - Explore novel processing schemes for the formation of nanoscale/biomolecular materials.
  - Explore the capabilities of quasicrystals, carbon nanotubes and other nanostructured materials for enhancing structural and functional performance of defense systems.
- Pathogen Countermeasures. (\$ 3.390 Million)
  - Develop novel initiatives to disrupt disease causing (virulence) factors in pathogens of concern to the DoD.
- Molecular Electronics. (\$ 10.000 Million)
  - Demonstrate that two interconnected molecules and/or nanoparticles show the anticipated functionality.
  - Demonstrate the ability to reversibly and repeatably transfer information from one molecule or nanoparticle to another.
  - Demonstrate that molecular and/or nanostructured materials can perform a storage function that can be driven from one state to the other by an external signal.

(U) **FY2001 Plans:**

- Nanoscale/Biomolecular Materials. (\$ 6.300 Million)
  - Demonstrate enhanced performance from materials and processes incorporating nanostructured components.
  - Demonstrate the use of quantum chemistry for the theoretical design of new nanoscale/biomolecular materials and structures.
- Molecular Electronics. (\$ 13.653 Million)
  - Demonstrate that molecules and/or nanoparticles can self-assemble into functional, regular, three-dimensional patterns forming a molecular memory.
  - Demonstrate assembly architectures that enable interconnected molecules and/or nanostructures to function even though some of the molecular components are defective.

(U) **Other Program Funding Summary Cost:** Not Applicable.

(U) **Schedule Profile:** Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE					September 1998
RDT&E, Defense-wide BA2 Applied Research					Next Generation Internet PE 0602110E					
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Next Generation Internet NGI-01	39,028	40,000	40,000	0	0	0	0	0	0	N/A

(U) Mission Description:

(U) The Next Generation Internet (NGI) initiative has three goals: (1) promote experimentation with the next generation of networking technologies; (2) connect universities and national laboratories with high speed networks that are 100 - 1000 times faster than today's Internet; and (3) demonstrate revolutionary applications that meet important national goals and missions. The principal agencies involved in this initiative are DARPA, NSF, NIST, NIH and NASA. These agencies will share in funding this research and development effort. The DARPA activity will be aimed at part of the first two goals. DARPA will demonstrate end-to-end network connectivity at 1+ gigabits-per-second for 10 or more NGI sites. The network technologies to be addressed include multi-gigabit broadband networks, guaranteed quality of service mechanisms, and integrated network management. These technologies will be demonstrated in an NGI developed testbed environment.

(U) Program Accomplishments and Plans:(U) FY1998 Accomplishments:

- Designed and initiated implementation of the NGI testbed. (\$ 7.028 Million)
- Created ultra high bandwidth Wavelength Division Multiplexed (WDM) connections for Next Generation Internet (NGI) testbed (Supernet). (\$ 15.000 Million)
- Developed NGI quality of service architecture and implemented initial operating system services. (\$ 15.000 Million)
- Executed Congressionally mandated adjunct to the NGI program. (\$ 2.000 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E, Project NGI-01	September 1998

(U) **FY1999 Plans:**

- Implement 10 gigabit-per-second, multi-wave optically switched WDM technology in NGI testbed. (\$ 5.000 Million)
- Implement an alpha-level prototype high-speed optical multiplexor and develop specification of IP/WDM protocol structure. (\$ 15.000 Million)
- Expand testbed to DoD supported laboratories and to 10 gigabit-per-second links. (\$ 5.000 Million)
- Implement prototype components of network monitoring and management system. (\$ 10.000 Million)
- Define application program interfaces for information management and collaborative applications. (\$ 5.000 Million)

(U) **FY2000 Plans:**

- Implement variable rate access technologies and prototype of distributed optical switching capability compatible with 100 Gb/s optical network. (\$ 6.000 Million)
- Implement streamlined Internet over Wavelength Division Multiplexed (WDM) protocol structure, eliminating two layers of existing telecommunications infrastructure. (\$ 11.000 Million)
- Develop network planning and simulation technology to meet requirements for NGI scale networks. (\$ 5.500 Million)
- Demonstrate real-time (500-msec response) monitoring and control of network resources at all levels. (\$ 3.500 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E, Project NGI-01	September 1998

- Complete interconnection of Supernet testbed components and software with 2.5 gigabit-per-second access architecture, up to 10 gigabit-per-second backbone, and 100 Gb/s distributed switching capacity. (\$ 9,000 Million)
- Demonstrate information management and collaborative applications operating over NGI testbed. (\$ 5,000 Million)

(U) FY2001 Plans: Not Applicable.

(U) Program Change Summary: (In Millions)

	<u>FY1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>
Previous President's Budget	40,500	40,000	40,000	0,000
Current Budget	39,028	40,000	40,000	0,000

(U) Change Summary Explanation:

FY 1998      Decrease results from minor program repricing and SBIR reprogramming.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost	
Total Program Element (PE) Cost	294,398	417,723	328,602	334,676	353,735	391,548	398,548	395,348	Continuing	Continuing	
JASON ST-01	1,289	1,200	1,200	1,200	1,200	1,200	1,200	1,200	Continuing	Continuing	
Intelligent Systems and Software ST-11	86,695	76,144	78,299	72,656	63,926	71,591	76,591	70,391	Continuing	Continuing	
High Performance and Global Scale Systems ST-19	149,462	196,483	172,863	183,595	191,727	198,329	200,329	203,329	Continuing	Continuing	
Software Engineering Technology ST-22	16,609	17,100	17,600	18,100	18,700	19,300	19,300	19,300	Continuing	Continuing	
Information Survivability ST-24	40,343	56,896	58,640	59,125	78,182	101,128	101,128	101,128	Continuing	Continuing	
Joint Infrastructure Protection ST-26	0	69,900	0	0	0	0	0	0	0	N/A	

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it funds projects directed toward the application of advanced, innovative computing systems and communications technologies.

(U) The High Performance and Global Scale Systems project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations.

(U) The efforts funded in the Intelligent Systems and Software project focus on the development of new information processing technology concepts that lead to fundamentally new software and intelligent system capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software intensive defense systems.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE		September 1998
	Computing Systems and Communications Technology PE 0602301E		

- (U) The Information Survivability project develops the technology base underlying the solutions to protecting DoD's mission-critical information systems against attack upon or through the supporting infrastructure. These technologies lead to generations of stronger protection, higher performance, and more cost-effective security solutions scalable to several thousand sites and to high-performance computing technologies.
- (U) The Joint Infrastructure Protection project examines national cyber defense threats to, and vulnerabilities of, critical infrastructures in the United States through research in the areas of information assurance and "other areas" of infrastructure protection such as intrusion monitoring and detection systems, information collection technologies, and data reduction and analysis tools.
- (U) The Software Engineering Technology project supports the Software Engineering Institute (SEI) that works to transition state-of-the-art technology, and best practices to improve the acquisition, engineering, fielding, and evolution of software-intensive DoD systems.
- (U) The JASON Group supports studies for the national security community.
- (U) **Program Change Summary: (In Millions)**
- |                             | <b><u>FY1998</u></b> | <b><u>FY 1999</u></b> | <b><u>FY 2000</u></b> | <b><u>FY 2001</u></b> |
|-----------------------------|----------------------|-----------------------|-----------------------|-----------------------|
| Previous President's Budget | 309.037              | 417.723               | 368.779               | 412.248               |
| Current Budget              | 294.398              | 417.723               | 328.602               | 334.676               |
- (U) **Change Summary Explanation:**
- FY 1998 Decrease reflects accelerated completion of the Human Computer Interaction effort stand-alone program and integration of the related technologies into other intelligent systems programs, and SBIR reprogramming.
- FY 2000-2001 Decrease reflects discontinuance of Adaptive Computing and Software Composition projects, and program restructuring and reprioritization in Defense Technology Integration and Data Intensive Systems and Software projects.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE					September 1998
RDT&E, Defense-wide BA2 Applied Research					Computing Systems and Communication Technology PE 0602301E, Project ST-01					
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
JASON ST-01	1,289	1,200	1,200	1,200	1,200	1,200	1,200	1,200	Continuing	Continuing

(U) Mission Description

(U) This project supports the JASONS, an independent group of distinguished scientists and technical researchers that provides analysis of critical National Security issues. JASON membership is carefully balanced to provide a wide spectrum of scientific expertise and technical analysis in theoretical and experimental physics, materials, information sciences, and other allied disciplines. The JASON process ensures senior government leaders have the full range of U.S. academic expertise available on issues critical to National Security involving classified and unclassified information.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Continued studies in: Counter proliferation of chemical and biological weapons; advanced sensors to support small unit operations; high bandwidth urban communications; characterization of underground facilities; novel energetic materials; small scale propulsion; and land mine detection. (\$ 1.289 Million)

(U) FY1999 Plans:

- Continue studies of interest to DoD in multiple disciplines such as: Counter proliferation of chemical and biological weapons; advanced sensor technologies; advanced computing; land mine detection; battlefield information systems; battlefield planning and control; small unit operations; military communications; and novel materials. (\$ 1.200 Million)

(U) FY2000 Plans:

- Continue studies of interest to DoD in multiple disciplines such as: Counter proliferation of chemical and biological weapons; space based radar; small payload space launch systems; advanced computing; multi-layered infrastructure defense; advanced sensor technologies

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communication Technology PE 0602301E, Project ST-01	September 1998

including increased radar noise floor and deep buried target characterization; dispersed land forces technology; battlefield information systems and military communications; ultra low power electronics; fiber lasers; and self monitoring materials. (\$ 1.200 Million)

(U) **FY2001 Plans:**

- Continue studies of interest to DoD. (\$ 1.200 Million)

(U) **Other Program Funding Summary Cost:** Not Applicable.

(U) **Schedule Profile:** Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide BA2 Applied Research					Computing Systems and Communications Technology PE 0602301E, Project ST-11						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Intelligent Systems and Software ST-11	86,695	76,144	78,299	72,656	63,926	71,591	76,591	70,391	Continuing	Continuing	

(U) Mission Description:

(U) This project develops new information processing technology concepts that will lead to fundamentally new software and intelligent systems capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software-intensive defense systems.

(U) Major areas of technical emphasis are: (a) active sensors and control strategies that leverage software-based intelligent processing to acquire sensory information, including advanced airborne video data, and prepare it for higher order processing by situation awareness and analysis tools; and to provide sophisticated control of subsystems and collections thereof; (b) situation analysis that provides for the intelligent integration of information from heterogeneous sources; interactive problem solving, planning, scheduling and decision analysis; and rapid development of large knowledge bases; and (c) presentation technologies that provide intelligent interfaces to the resultant information streams, including the integration and application of emerging language understanding to address both C4I and intelligence community needs.

(U) As this program matures, it will have a reduced emphasis on software composition, i.e., the methodology and tools used to compose intelligent software. Beginning in FY 2000, there will be an increased emphasis on the development of intelligent applications that leverage the composition tools developed in the earlier phase of the project. Specific application domains of interest are situation analysis, situation presentation, and the processing of sensor-derived information.

(U) Program Accomplishments and Plans:(U) FY1998 Accomplishments:

- Software Composition. (\$ 30.395 Million)
  - Integrated selected Rapid Design Exploration and Optimization (RaDEO) designed computation tools that demonstrate robust multi-disciplinary design. Demonstrated a 5X reduction in early design trade-off time by combining qualitative & quantitative models.

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- Released design of Formal Language for Expressing Assumptions.
- Released Version 2 of core architectural description interchange language (ACME) and demonstrated use of ACME to represent multiple domain-specific software models.
- Released real-time dynamic language system for use by Integrated Feasibility Demonstration teams.
- Completed Computer Aided Education and Training Instruction (CAETI) effort to enhance training environments.
- Executed Congressionally mandated Reuse Technology Adoption Program (RTAP).
- Active Sensors. (\$ 22.258 Million)
  - Developed, demonstrated, and evaluated image understanding technologies for image exploitation, automatic population of geospatial database, video surveillance and monitoring, and automatic target recognition to enhance battlefield awareness.
  - Developed concept of operations for Airborne Video Surveillance (AVS) system in cooperation with government video surveillance users. Developed AVS detailed system design and multi-year technology build/evaluate plan. Collected ground truthed data of events and moving targets at the Fort A.P. Hill experimental site and used this data for late FY 1998 laboratory demonstrations of precision video registration (PVR), activity monitoring (AM), and moving target surveillance (MTS) technology.
  - Supported software initiatives at the National Applied Software Engineering Center (NASEC); Johnstown, PA.
- Situation Analysis. (\$ 34.042 Million)
  - Developed initial prototypes for multi-language text extraction and audio transcription where performance is baselined against that of human operators.
  - Continued development of modular Human Language Technologies to support easy, low-cost, rapid technology transfer and application development for Document Understanding, Machine Translation, and Speech Understanding.
  - Integrated human-in-the-loop, automated planning, and decision aids techniques for managing military command and control processes in quickly-changing operational settings; demonstrated capabilities to generate, assess, and select among multiple alternative plans in the same amount of time currently required to generate one plan.
  - Used unified ontologies in tools for focused knowledge acquisition; extended learning methods; and added new high-performance, problem-solving methods to the High Performance Knowledge Base library for battlefield awareness, crisis management, and military command and control.

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- Developed, in the Intelligent Integration of Information area, tools and techniques to enable the rapid construction of information fusion, aggregation, and summarization software to filter, access, and integrate information from 100s of disparate, heterogeneous, distributed data sources.

(U) **FY1999 Plans:**

- Software Composition. (\$ 21.573 Million)
  - Conduct Instrumented Feasibility Demonstration (IFDs) of evolutionary design technologies; IFD participants include USTRANSCOM, Joint STARS, and B2 software maintenance.
  - Investigate active approaches to software composition, with emphasis on aspect-oriented programming; on-the-fly component generation & interconnection; and module self-evaluation and configuration.
  - Demonstrate a 2X reduction in detailed design by integrating Design Web and Computational Tools made for multi-disciplinary optimization.
  - Demonstrate web-based toolkit of representation, analysis and generation tools.
- Active Sensors. (\$ 25.084 Million)
  - Integrate most successful new image understanding and automatic target recognition technologies into feasibility demonstrations for video image exploitation, synthetic environments, and video surveillance; demonstrate & evaluate impact of embedded image understanding technologies on battlefield awareness.
  - Integrate, demonstrate and evaluate laboratory and airborne systems in a simulated cantonment area monitoring scenario, with these technology goals: Activity Monitoring - Detect soldier incursion and removal of restricted vehicles from a small area or point; Moving Target Surveillance - maintain track on the removed vehicles, with reliable target re-acquisition as the sensor is multiplexed and tracks are occluded by trees; Precision Video Registration - geolocate moving and stationary vehicles in 80% of the video sequences within 5-10 meters of ground truth.

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- Situation Analysis. (\$ 29.487 Million)
  - Develop language comprehension technology to provide extraction of content and production of summary information focused on information access, manipulation and creation tasks in order to demonstrate improved readiness for military planning and situation awareness.
  - Develop and demonstrate fully automatic algorithms to determine the structure of radio and TV news broadcasts in several languages allowing military planners and intelligence analysts to detect and track emerging topics.
  - Develop and demonstrate a large, integrated situation assessment knowledge base through reuse of knowledge base components from heterogeneous sources.
  - Define a million axiom knowledge base construction problem and competency test for a military challenge problem requiring technical, military strategy and tactics, and geopolitical knowledge.
  - Demonstrate the utility of man-machine planning and execution control against an aggressive adversary in a realistic simulation of an operational environment and transition to applications and systems programs.
  - Demonstrate and transition Intelligent Integration of Information tools and techniques to enable the rapid construction of large-scale information associates to filter, access, and integrate information from 100s of disparate, heterogeneous data sources.

(U) FY2000 Plans:

- Active Sensors. (\$ 29.000 Million)
  - Develop fully automated video sentries detecting and tracking a skilled infantry squad attempting ingress to a built up site from wooded, grassy, and open terrain over a 24 hour period using an array of cooperating visual and thermal sensors.
  - Specify gradient-based approach to automated aggregation and distribution of information from large numbers of multi-sensor nodes.
- Situation Analysis. (\$ 28.100 Million)
  - Demonstrate statistically based semantic analysis capabilities across four repositories, at least one of which supports access controls.
  - Define ontologies, knowledge bases, and reasoning methods for an initial prototype of a large-scale (500K+-axiom) battlespace knowledge base that represents and reasons about transnational threats including assessments of threat activity and predictions of future events.

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- Demonstrate translanguag document clustering for representative European and Asian languages.
- Situation Presentation and Interaction within Smart Spaces. (\$ 21.199 Million)
  - Specify network-based service architecture/API's for key components of dialogue architecture; using metrics-based evaluation, demonstrate usability of dialogue interaction with confirming sub-dialogue to reduce task completion time by 80% for a travel reservation task.
  - Specify challenge scenarios, metrics and measurement techniques for competitive evaluation of multi-modal presentation technologies.
  - Demonstrate language and diagram interface, analogic reasoners, and theory explanation capabilities, as well as, develop 10-20 core theories (5K-10K axioms each).

(U) FY2001 Plans:

- Active Sensors. (\$ 25.000 Million)
  - Demonstrate real-time detection of anomalous behavior in streets and indoor scenes by a cooperating sensor array to be followed by tracking targeted subjects with high resolution sensors for automated comparison with a catalog of known subjects.
  - Experimental demonstration of automated aggregation and distribution of information involving at least 100 nodes and 300 sensors.
- Situation Analysis. (\$ 23.200 Million)
  - Deploy scalable prototype analysis environment in defense application with cross-repository information analysis functionality (semantic retrieval, indexing, value filtering, user defined alerting, categorizing, and interoperability).

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- Demonstrate initial (75K axiom) transnational threat knowledge base describing the organization and behavior of threat entities and consisting of general purpose and domain specific knowledge acquired through reuse of existing ontologies, acquisition of knowledge from domain experts, extraction of knowledge from the web, text and other sources and discovery of knowledge from transnational threat data bases.
  - Demonstrate direct knowledge entry by a novice (2K axioms/month).
  - Extract, translate, and correlate named entities from unstructured documents in multiple languages.
- Situation Presentation and Interaction within Smart Spaces. (\$ 24.456 Million)
  - Engineering integration of key components of dialogue architecture.
  - Demonstrate and evaluate dialogue performance for Project Marine; complete a complex travel task requiring negotiation twice as fast with automated service support as with the best human assistance.
  - Alpha level prototype of modality coordinator for speech, gestures and mouse interactions.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide BA2 Applied Research					Computing Systems and Communications Technology PE 0602301E, Project ST-19						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
High Performance and Global Scale Systems ST-19	149,462	196,483	172,863	183,595	191,727	198,329	200,329	203,329	Continuing	Continuing	

(U) Mission Description:

(U) This project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations. The project is comprised of the following components:

- The Global Mobile Information Systems effort will enable mobile users to access and utilize the full range of services available in the Defense Information Infrastructure. To achieve this goal, it will develop nomadic technologies and techniques at the applications, networking, and wireless link/node levels.
- The Networking component develops active networking technologies and associated network management capabilities to support deeply networked systems. Research is coordinated with DoD, NASA, DoE, NSF, and other federal agencies.
- The Data Intensive Systems and Software component develops software and hardware technologies for data-starved applications. This component will develop a new approach to computer memory organization that will eliminate severe bottlenecks in present designs.
- The Adaptive Architectures component develops new approaches to the design of computer hardware that incorporates dynamic configuration capabilities. The resultant devices will allow DoD to develop a wide variety of specialized systems by reusing a relatively small set of hardware designs, each of which can be affordably produced in high volumes.
- The Systems Environments component develops scalable software which is tailored toward easing the use of systems by application programmers. This includes run-time services, resource allocation, and experimental applications.

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- The Embeddable Subsystems component is developing node level technologies for use in embedded systems that leverage novel control and signal processing technologies.
  - The Autonomous Software component develops common software capabilities that can be re-used across a range of DoD autonomous systems, including mobile platforms, such as Unmanned Air Vehicles (UAVs), and fixed environments such as distributed sensor-to-shooter applications.
  - The Scalable Infrastructure component is developing new system capabilities to support future environments involving hundreds or thousands of networked nodes per warrior. This component will also enable global instrumentation of DoD assets.
- (U) Each of the above components of this program will integrate capabilities developed under the Information Survivability initiative (Project ST-24) to satisfy defense requirements for secure systems.
- (U) Program Accomplishments and Plans:
- (U) FY1998 Accomplishments:
- Global Mobile Information Systems. (\$ 14.837 Million)
    - Demonstrated middleware services for adapting applications to changing infrastructure resources.
    - Developed advanced algorithms and components for waveform processing at untethered nodes.
    - Developed software modules for reconfigurable radios.
    - Conducted integrated technology demonstrations.
  - Networking. (\$ 20.526 Million)
    - Implemented prototypes of Enhanced Networking Services utilizing composable modules.
    - Completed prototype implementation of active node execution environment; of fast compiler for SmartPacket Methods; and of basic management functions.
    - Initiated operation of wide area Active Network on prototype platforms.

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- Scalable Systems and Software. (\$ 35.431 Million)
  - Scalable Computing.
    - ◆ Demonstrated highly efficient, parallel nodes; auto-parallelization of file input/output (I/O) for scalable systems; first node-level performance of ultra-low-power systems; and distributed, shared-memory support for a commodity processor.
  - Ultrascale Computing.
    - ◆ Assessed quantum-to-Si hardware and software interface; and language for expressing amorphous algorithmic computations.
    - ◆ Demonstrated 256-component addressed array of molecular computational mechanisms; and evaluated surface patterning mechanisms for culturing neural components on silicon.
  - Scalable Software.
    - ◆ Demonstrated fault-tolerant allocation of 100K-entity synthetic force simulation on 1,300 nodes spanning 13 machines at 9 sites.
- Microsystems. (\$ 28.191 Million)
  - Demonstrated formal methods for microprocessor verification.
  - Demonstrated integrated environment for design of advanced microcomponents.
  - Developed novel subsystem designs that use configurable component technology.
  - Demonstrated adaptive template matching concept through software prototype capable of automated runtime remapping.
- Embeddable Computing. (\$ 14.607 Million)
  - Demonstrated utility of embeddable computing technology in unmanned undersea vehicle (UUV) real-time testbeds.
  - Demonstrated extremely high-density Digital Signal Processing (DSP) packaging and thermal dissipation technologies capable of achieving 1 TFlop/cu. ft.
  - Released initial versions of space-time adaptive processing (STAP) algorithm tools and libraries.
  - Developed domain-specific development tools with visualization capability and MatLab compatible system generator.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19	September 1998

- Systems Environments. (\$ 13.123 Million)
  - Demonstrated experimental versions of new iterative solvers for radar cross-section modeling; languages and runtime services supporting parallel applications such as Advanced Distributed Simulation; and HPC++ languages and runtime services supporting both task and data parallelism.
- Defense Technology Integration and Infrastructure. (\$ 22.747 Million)
  - Information Management.
    - ◆ Developed algorithms to effectively search collections of documents for words used only in restricted senses; and design query and preference languages incorporating similarity and value filtering.
    - ◆ Investigated statistical co-occurrence techniques for texture classification of images.
  - Intelligent Collaboration and Visualization.
    - ◆ Developed initial library of collaboration middleware for data sharing, coupling and coordination.
    - ◆ Demonstrated real-time capability to discover at least 60% of relevant collaborators using graph-matching algorithms.
    - ◆ Demonstrated initial capability for teams to control shared, time-varying visualization models.
    - ◆ Demonstrated initial capability for semantic access to timed event streams and multimedia archives.

(U) FY1999 Plans:

- Global Mobile Information Systems. (\$ 20.300 Million)
  - Demonstrate application support for distributed computing in mobile environments and continuous multi-tier networking across wireless domains.
  - Prototype implementation of integrated high data-rate untethered node.
- Networking. (\$ 31.440 Million)
  - Investigate alternative approaches to large-scale network management and engineering including self-organizing simulation technology.
  - Extend operation of Active Network testbed to traverse ~10 sites of ~10 switches; each using SmartPackets and composite protocols.
  - Demonstrate active node execution environment supporting resource protection, security, and survivability functions.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19	September 1998

- Scalable Systems and Software. (\$ 37.520 Million)
  - Scalable Software.
  - ♦ Release scalable versions of defense-critical engineering software.
  - Data Intensive Computing Systems.
  - ♦ Demonstrate multiprocessor RISC chip (16 issue, 1.6 GOP, 5-cycle message latency).
  - ♦ Investigate instruction set extensions and storage components to allow defense applications to specify whether operations are executed in the central processor or in logic circuits embedded in the memory hierarchy.
  - Ultrascale Computing.
  - ♦ Conduct system-level design and simulation study of a computation model-based on large amorphous arrays.
  - ♦ Establish role of Nuclear Magnetic Resonance (NMR) technologies in development of ultrascale computing.
- Adaptive Computing Architectures. (\$ 28.609 Million)
  - Debug and validate novel, configurable component technologies and architectures; demonstrate use of adaptive building blocks in wireless radio applications.
  - Demonstrate 100x user-level software performance improvement over commodity microprocessors on challenge problems; release new algorithm design software environment optimized to leverage adaptive technology.
- Systems Environments. (\$ 15.739 Million)
  - Performance-Driven Compiler and Library Technologies.
  - ♦ Demonstrate experimental scalable structural dynamics application using DARPA sparse matrix library.
  - Load Adaptive Run-time Environments.
  - ♦ Demonstrate microfeedback technologies for adaptive services.
  - ♦ Release prototype subsystem supporting adaptive resource allocation and consumption in response to changing workload and resource availability.
- Embeddable Microsystems. (\$ 29.875 Million)
  - Tactical Signal Processing.
  - ♦ Publish benchmarks for embedded signal processing.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE	
	Computing Systems and Communications Technology PE 0602301E, Project ST-19	

- ◆ Demonstrate enabling technologies including: Discrete Fourier Transform (DFT) chips based on clockless logic, Single Instruction Multiple Datastream (SIMD) and multi-DSP board designs, Myricom 2.5 Gbps high speed configurable interconnect.
- ◆ Develop compiler and code generators to permit retargeting of commercial signal processing tools to suit tactical signal processing environments.
- Hybrid Information Appliances.
- ◆ Evaluate alternative mechanisms for embedded logic & communications subsystems that incorporate biological materials with potential to achieve size, weight and power reductions of >10 over electronic-only equipment.
- ◆ Investigate techniques, which transduce electrical/optical/magnetic signals to/from chemical and/or biological processes.
- Hands-Free Interfaces.
- ◆ Develop algorithms to deal with high noise conditions for speech recognition.
- Defense Technology Integration. (\$ 33.000 Million)
  - Information Management.
  - ◆ Develop framework for federation of text, image and relational databases.
  - ◆ Demonstrate presentation aids for military type documents in English, Korean and a European language.
  - ◆ Validate design of secure repository architecture for digital objects up to 100 megabytes in size.
  - Intelligent Collaboration.
  - ◆ Integrate application-specific and generic collaboration middleware.
  - ◆ Develop Session Management middleware, leveraging multicasting technology that adjusts to variations in bandwidth & connectivity.
  - ◆ Develop tools that enable teams and individuals to retrieve situation and task relevant information from static and dynamic archives containing a record of experiences from multi-sensory sources; and adjust team dynamics in real-time in response to changes in mission and situation.

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(U) FY2000 Plans:

- Global Mobile Information Systems. (\$ 18.900 Million)
  - Beta-level prototype of high data-rate untethered node incorporating miniature codec.
  - Prototype implementation of mobile wireless Asynchronous Transfer Mode (ATM) networks.
  - Integrate GloMo simulation models and conduct scenario simulations for 100+ node network.
- Networking. (\$ 23.832 Million)
  - Demonstrate use of active network approach to achieve live protocol updates within two roundtrip times.
  - Release of prototype Active Network toolkits for end-user stations and network elements including performance measurement capabilities.
  - Engineering analysis of Active Network performance.
  - Initiate transfer of global scale networking technologies into distributed operational testbeds.
  - Evaluate alternative protocol and addressing structures for deeply networked systems.
- Data Intensive Systems and Software. (\$ 28.231 Million)
  - Design processor in memory VLSI components that support in situ processing of application data.
  - Implement compiler that generates code compatible with processor in memory architecture.
  - Simulate data-intensive systems, demonstrating 10-fold performance improvement on critical DoD applications.
- Adaptive Computing Architectures. (\$ 36.739 Million)
  - Prototype implementation and runtime libraries supporting adaptive performance monitoring and analysis.
  - Demonstrate automated, model-based synthesis of heterogeneous Digital Signal Processing (DSP), Application Specific Integrated Circuit/Field Programmable Gate Array (ASIC/FPGA), General Purpose (GP) system designs for large-scale systems.
  - Establish Adaptive Computing System challenge problem testbed for experimental development of 1 cubic foot ATR system.

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- Systems Environments. (\$ 16.200 Million)
  - Release reference implementation of mission-critical Quality of Service (QoS) architecture.
  - Release prototype operating system with partitioned resource management for strict QoS guarantees.
  - Joint demonstration with AdCon-21 employing C4ISR sensor data for targeting with total reallocation latency of less than 5 seconds.
- Embeddable Subsystems. (\$ 25.961 Million)
  - Tactical and Bio-Digital Signal Processing.
    - ◆ Implement prototype multiprocessor event collection and analysis system and automated stress test generator for signal processing applications; demonstrate use of high performance signal processing for weapon systems applications.
    - ◆ Develop architecture for tactical signal processing based on deeply networked systems approach.
    - ◆ Develop minimally invasive imaging tools for monitoring the state of ongoing biological experiments.
  - Software Enabled Control.
    - ◆ Specify architecture for a hybrid control system that synthesizes the control law approach with computationally enabled mode logic scalable to very large state spaces of 100K+ states.
    - ◆ Implement alpha-level prototype of a control system that utilizes active model technology.
- Autonomous Software. (\$ 11.000 Million)
  - Develop goal tracking requirements for autonomous software.
  - Develop framework for bottom-up organization of autonomous software.
  - Define challenge problems and metrics for autonomous software.
- Scalable Infrastructure. (\$ 12.000 Million)
  - Identify alternative approaches to location, identification, and determination of capabilities of active components.
  - Specify common services for scalable active software.
  - Develop application framework for global asset instrumentation based on active software.
  - Investigate new approaches to large-scale software composition based on software tolerances and redundancy instead of absolute correctness; identify relevant challenge problems.

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(U) FY2001 Plans:

- Global Mobile Information Systems. (\$ 19,000 Million)
  - Demonstrate secure multicast services over multihop, multimode network.
  - Field demonstration of proxy-enabled distributed computing in mobile environments.
- Networking. (\$ 24,000 Million)
  - Demonstrate performance improvements of 100% for large multicast sessions based on active suppression of redundant acknowledgement and retransmission messages.
  - Demonstrate use of active network technology to enhance mobile/nomadic network-based services and protocols.
  - Continue transfer of global scale technologies into distributed operational testbeds.
  - Prototype implementation of network software and application interfaces for deeply networked systems.
  - Identify challenge problems and metrics for deeply networked systems comprising 100+ nodes per vehicle.
- Data Intensive Systems and Software. (\$ 28,380 Million)
  - Data Intensive Computing Systems.
    - ◆ Prototype fabrication of processor in memory VLSI components that support in situ processing of application data.
    - ◆ Conduct bench experiments to demonstrate that fabricated components achieve performance predicted by simulations.
    - ◆ Conduct bench experiments to demonstrate in situ processing of model-based ATR data at 100,000 ray-patch intersections per second.
  - Ultrascale Computing.
    - ◆ Demonstrate application of amorphous array and artificial nervous system to defense-related problems.
- Adaptive Computing Architectures. (\$ 33,300 Million)
  - Reconfigurable Architectures.
    - ◆ Release beta version of Adaptive Computing Systems (ACS) software including compilers and support for commercial design environments such as MatLab and Khoros; demonstrate 10x improvement in compilation times.

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- ♦ Demonstrate application of ACS technology to challenge problems, including JSTAR-based ATR, RF transient signal analysis and sonar adaptive beamforming.
- ♦ Demonstrate self test diagnosis and reconfiguration to circumvent defective and/or damaged portions of commodity logic components.
- Reconfigurable Kernels.
- ♦ Investigate alternative approaches to the interfaces and structure of reconfigurable kernels suitable for use in adaptive computing environments.
- Systems Environments. (\$ 17.000 Million)
  - Release prototype distributed object software with real-time QoS management.
  - Demonstrate support for mixed workloads of hard, soft, and non-real-time applications.
  - Demonstrate QoS-driven fault detection and recovery within 500 msec.
- Embeddable Subsystems. (\$ 27.415 Million)
  - Tactical and Bio-Digital Signal Processing.
    - ♦ Specify standard Application Program Integration (API) for data shaping and data mapping of embedded defense applications; develop prototype of visual program compiler and code generator.
    - ♦ Implement prototype system demonstrating integration of deeply networked sensors and tactical signal processing technologies.
    - ♦ Demonstrate use of high resolution imaging technology and signal transduction to effect interactive control over simple biological systems.
  - Software Enabled Control.
    - ♦ Distribute a software-enabled control toolkit that facilitates development of multi-level, multi-model control systems.
    - ♦ Demonstrate effectiveness of software-enabled control in the context of mission-critical embedded applications such as engine control, flight maneuver, integrated avionics and coordinated control of multiple systems.

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- Autonomous Software. (\$ 17.500 Million)
  - Specify negotiable behaviors to be supported by autonomous software.
  - Prototype demonstration of goal tracking ability under changing environments.
  - Implement prototype that demonstrates negotiation and behavioral tradeoffs; demonstrate ability to predict and shortcut negotiation.
  - Select platforms for use in challenge problem implementation.
- Scalable Infrastructure. (\$ 17.000 Million)
  - Alpha-level implementation of Common Operating Environment (COE) for scalable active software.
  - Demonstrate ability to identify and characterize active components needed to dynamically form propose/bid hierarchies.
  - Prototype demonstration of global asset instrumentation based on active software COE.
  - Experimental evaluations of software tolerance concept; down select to most providing options for further development and challenge problem demonstrations.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Software Engineering Technology ST-22	16,609	17,100	17,600	18,100	18,700	19,300	19,300	19,300	Continuing	Continuing	

(U) Mission Description:

(U) Software is key to meeting DoD's increasing demand for high quality, affordable, and timely national defense systems. There is a critical need to rapidly transition state-of-the-art technology and best practices to improve the acquisition, engineering, fielding, and evolution of software-intensive DoD systems. In FY 2000 this project will fund the technology transition activities of the Software Engineering Institute (SEI) at Carnegie Mellon University. The SEI is a Federally Funded Research and Development Center (FFRDC) sponsored by the Office of the Under Secretary of Defense for Acquisition and Technology. It was established in 1984 as an integral part of the DoD's software initiative to identify, evaluate, and transition high leverage technologies and practices and to foster disciplined software engineering practices by DoD acquisition and life cycle support programs and within the industrial base where the bulk of defense software is produced. The Institute works across government, industry, and academia to: (1) improve current software engineering activities from both management and engineering perspectives; (2) facilitate rapid, value-added transition of technology to practice; and (3) evaluate and calibrate emerging technologies to determine their potential for improving the evolution of software-intensive DoD systems.

(U) The SEI enables the exploitation of emerging software technology by bringing engineering discipline to software acquisition, development, and evolution. The SEI focuses on software technology areas judged to be of the highest payoff in meeting defense needs. FY 1997 and FY 1998 focus areas were: Technical Engineering Practices (including Information Survivability practices, Architecture-centered Software Engineering, and COTS-Based Software Engineering), Enhanced Software Management Capabilities (including Software Process Improvement and Capability Maturity Model Integration (CMMI)), and Accelerating Adoption of High Payoff Software Technologies.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22	September 1998

(U)

Program Accomplishments and Plans:

(U)

FY1998 Accomplishments:

- Technical Engineering Practices: Defined and documented administrative process and procedures for global incident response coordination. Processed guides for global incident response coordination to be used by collaborating incident response teams. A vulnerability knowledge base used by response teams was enhanced to support the collection, analysis, and sharing of security incident data. Architectural patterns supporting the integration of COTS components have been identified. Attribute-specific survivability patterns for COTS-based architectures and legacy systems were demonstrated. (\$ 9,400 Million)
- Enhanced Software Management Capabilities: Integrated and enhanced models for software processes, process improvement methods, and analytical capabilities to provide a common base for process assessments and improvement analysis. Released software and systems model under the CMMI framework for stakeholder review. Initiated operation of a repository for DoD software measurement data and risk management experience; released software measurement handbook and risk evaluation guidebook. (\$ 5,400 Million)
- Adoption of Software Technologies: Developed guidebook for introducing technology change into organizations. Demonstrated potential utility of collaborative process technology for enhancing cooperation in responding to information warfare attacks. Provided software measurement support to all initiative work to ensure performance measures were established. (\$ 1,809 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22	September 1998

(U) FY1999 Plans:

- Technical Engineering Practices: Architecture evaluation guidelines and tradeoff techniques are demonstrated for use with survivable systems; an initial version of a security improvement tool kit developed to help system administrators protect their systems against current and emerging threats; pilot tests of an incident response collaboration support system, including an incident and vulnerability knowledge base, are conducted. Architecture evaluation techniques for COTS-based systems are being used to reduce costs and risk. Training in the development of COTS-based systems is available. (\$ 9.400 Million)
- Enhanced Software Management Capabilities: Release of the integrated models (software, systems, and IPPD) under the CMMI framework for public review and pilot test. Publication of Version 1 of CMMI support products. CMMI is harmonized with International standards. Initial release of Team Software Process training. (\$ 5.900 Million)
- Adoption of Software Technologies: Upgraded and expanded measurement information repository will be released to define the benefits and costs of technical practices; updated courses in software engineering measurement are packaged to support DoD training needs. (\$ 1.800 Million)

(U) FY2000 Plans:

- Technical Engineering Practices: Define and document administrative process and procedures for global incident response coordination. Process guides for global incident response coordination are used by collaborating incident response teams. A vulnerability knowledge base used by response teams is enhanced to support the collection, analysis, and sharing of security incident data. Architectural patterns supporting the integration of COTS components will be identified. Attribute-specific survivability patterns for COTS-based architectures and legacy systems are demonstrated. (\$ 9.800 Million)
- Enhanced Software Management Capabilities: Update and release of version 2 of the CMMI products based on Government and industry use and feedback. (\$ 5.900 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22	September 1998

- Adoption of Software Technologies: Develop guidebook for introducing technology change into organizations. Demonstrate potential utility of collaborative process technology for enhancing cooperation in responding to information warfare attacks. (\$ 1.900 Million)
- (U) **FY2001 Plans:**
- Technical Engineering Practices: Exemplar architectures for survivable systems in use by DoD and industry. Standard COTS evaluation practices are defined and in use to support the development of COTS-based systems. (\$ 10.000 Million)
- Enhanced Software Management Capabilities: Research to support software process and product improvement, by reducing redundancy and complexity. This will improve the efficiency of and the return on investment for software development. (\$ 5.900 Million)
- Adoption of Software Technologies: Standard practices for adopting technology are in widespread use. (\$ 2.200 Million)

(U) **Other Program Funding Summary Cost:** Not Applicable.

(U) **Schedule Profile:** Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-26						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Joint Infrastructure Protection ST-26	0	69,900	0	0	0	0	0	0	0	N/A	

(U) Mission Description:

(U) The President's Commission on Critical Infrastructure Protection was established by Executive Order in July 1996 to examine the physical and national cyber defense threats to (and vulnerabilities of) critical infrastructures in the United States. As a result, this commission increased the DoD research and development investment for information assurance research and "other areas" of infrastructure protection (i.e., improved system and network protection, intrusion monitoring and detection systems, information collection technologies, and data reduction and analysis tools). This initiative is expected to be organized around four general thrusts; developing technologies to build hardened information systems and networks that: (1) have strong barriers to attack, (2) can detect malicious and suspicious activity, (3) can isolate and repel malicious and suspicious activity, and (4) can guarantee minimum essential continued operation of critical system functions in the face of concerted information attacks. It is further expected that, because of its extreme timeliness and importance, this initiative will be conducted in very close partnership, if not jointly, with the Military Departments and with the full involvement of the Chief Information Officer (CIO) of each Service.

(U) Program Accomplishments and Plans:(U) FY1998 Accomplishments:

- New Start in FY 1999.

(U) FY1999 Plans:

- Create information warfare indications and warning tools. (\$ 15,000 Million)
- Create intrusion detection effectiveness testbed and flexible tools & metrics to assess CII components. (\$ 7,000 Million)
- Develop and harden adaptive system response to attack. (\$ 7,000 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-26	September 1998

- Improve system survivability through decentralized system organizations. (\$ 5.000 Million)
- Improve and harden network security tools to address denial of service. (\$ 8.900 Million)
- Develop security solutions for dynamic databases and object systems. (\$ 7.000 Million)
- Harden and integrate cooperating intrusion detectors. (\$ 5.000 Million)
- Demonstrate and transition infrastructure protection technologies to national critical infrastructure systems such as the military's command and control systems and to the constituent commercial and customized components that comprise such systems. (\$ 15.000 Million)

- (U) FY2000 Plans: Not Applicable.
- (U) FY2001 Plans: Not Applicable.
- (U) Other Program Funding Summary Cost: Not Applicable.
- (U) Schedule Profile: Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE		September 1998	
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE								
RDT&E, Defense-wide BA2 Applied Research					Biological Warfare Defense PE 0602383E								
COST (In Thousands)		FY 1998	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost		
Biological Warfare Defense Program BW-01		58,452	88,000	148,500	151,000	151,500	135,800	116,800	113,800	Continuing	Continuing		

(U) Mission Description:

(U) The Biological Warfare Defense program is budgeted in the Applied Research budget activity (BA-2) because its focus is on the underlying technologies associated with pathogen detection and remediation. Today, there is a tremendous mismatch between the magnitude of the biological warfare threat and the Department's ability to adequately respond. The widespread availability of bacterial, viral, and toxin stocks; minimal developmental cost and scientific expertise required; and abundance of weaponization potential comprise a sinister threat. The single largest concern, however, is from the exploitation of modern genetic engineering by adversaries to synthesize "super pathogens." Recent dramatic developments in biotechnology, which this program will leverage, promise to eliminate this mismatch. This program funds projects supporting revolutionary new approaches to biological warfare (BW) defense.

(U) Efforts to counter the BW threat include developing barriers to block entry of pathogens into the human body (including unique methods for rapid air and water purification), pathogen countermeasures to stop pathogen virulence and to modulate host immune response, medical diagnostics for the most virulent pathogens and their molecular mechanisms, biological and chemically-specific detectors, and consequence management tools. Program development strategies include collaborations with pharmaceutical, biotechnology, government, and academic centers of excellence.

(U) Pathogen countermeasures (e.g., Anti-Virals/Immunizations, Anti-Bacterials/Anti-Toxins, Multi-Purpose, and External Protection) under development include: (1) multi-agent therapeutics against known, specific agents and (2) therapeutics against virulence pathways shared by broad classes of pathogens. Specific approaches include modified red blood cells to sequester and destroy pathogens, modified stem cells to detect pathogens and produce appropriate therapeutics within the body, identification of virulence mechanisms shared by pathogens, development of therapeutics targeting these mechanisms, efficacy testing in cell cultures and animals, and advanced non-toxic decontamination strategies.

(U) In the early stages, many illnesses caused by BW agents have flu-like symptoms and are indistinguishable from non-BW related diseases. Early diagnosis is key to providing effective therapy. The advanced diagnostics efforts will develop the capability to detect the presence of infection

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01	September 1998

by biological threat agents, differentiate them from other significant pathogens, and identify the pathogen, even in the absence of recognizable signs and symptoms (when the pathogen numbers are still low).

(U) The ability to detect biological warfare agents on the battlefield in real time with no false alarms is a crucial requirement. To address this need, the program is creating more efficient and effective miniature sampling technologies that concentrate contaminated air and enhance the ability to capture biological warfare agents. The program is developing a new range of antibodies and "designer small molecules" to bind specific agents (to replace the lower affinity antibodies currently used). In order to detect that the binding of an agent has occurred, the event must be "magnified." Traditionally, this is done by tagging the antibody molecule with a fluorescent probe. This program is replacing the noise-plagued fluorescent tags with Up-Converting Phosphors with the sensitivity to detect a single binding event, minimizing the size of the sample required, saving time, and decreasing the number of false positive alarms. The use of fluids as a requirement for biological agent detection is also being eliminated and replaced by a miniaturized (shoe box-size) time-of-flight mass spectrometer. Development of a bacterial biochip to identify genus and species without multiplying the DNA by the polymerase chain reaction (PCR) is also under development, thereby saving at least 20 minutes in time to identification. Additional efforts are focusing on the construction of molecular, cellular, and multicellular sensors for the rapid detection of biological threats. These cellular and tissue-based sensors have the ability to respond to both known and unknown threats and determine live vs. inactivated threat status.

(U) Mission effectiveness requires rapid, correct medical responses to biological weapon threats or attacks. A portion of this project will provide comprehensive protocols to protect or treat combatants by using current and emerging biological countermeasures. It will provide accelerated situational awareness for biological warfare events by detecting exposure to agents through an analysis of casualty electronic theater medical records and will locate and determine the most effective logistical support for providing appropriate treatment and pathogen-specific resources required to mitigate effects of the attack.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Pathogen Countermeasures. (\$ 43.086 Million)
  - Optimized the detection of specific pathogens by stem cells (in cell culture).

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01	September 1998

- Determined the impact of modified red blood cells on vascular and immune systems.
  - Defined animal models in which to test the efficacy of modified red blood cells to defend against pathogens.
  - Developed enzymes and other active molecules which can be attached to the surface of red blood cells to detect and destroy pathogens.
  - Established a portfolio of strategies to:
    - Inhibit the expression of disease causing (virulence) factors by pathogens.
    - Disrupt the disease causing (virulence) communications between pathogens.
    - Modulate the body's response to the presence of a pathogen.
    - Assess the feasibility of novel polymeric materials to protect against pathogen exposure.
  - Assessed the feasibility of an array-based instrument (and other novel technologies) for multi-agent pathogen diagnosis in medical samples.
- Sensors. (\$ 7.788 Million)
    - Developed a hierarchical database of mass signatures for use in detecting selected bacteria with a mass spectrometer.
    - Investigated methods for determining biological warfare agent bacterial and viral viability (agent live or dead).
    - Demonstrated the feasibility of using giant magnetoresistance for the detection of magnetic bead-tagged pathogens.
    - Fabricated and tested a wick device, an integral sample pump, and a reagent reservoir system suitable for use in a handheld Up-Converting Phosphor detector.
    - Developed a biochip for rapid pathogen identification.
    - Engineered cells for pathogen specificity and amplification.
    - Engineered cells with optical signals in response to pathogen detection.
    - Identified limiting performance variables for cells in tissue based detection schemes.
  - Consequence Management. (\$ 7.578 Million)
    - Demonstrated a biological warfare Anchor Desk that provides agent-specific biological warfare (BW) situational awareness, decision and execution support with linkages to the Logistics Anchor Desk (LAD) for BW-specific logistical information.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01	September 1998

- Developed agent-specific "software antibodies" for detection, protection, and treatment directives to medical personnel for BW threats that will decrease response time.
- Developed quantitative measures of operational assessment using Medical Readiness Indicators (metrics based indicators of individual and unit level readiness) and realistic BW training algorithms to improve the medical response to a biological warfare incident.
- Demonstrated Enhanced Consequence Management Planning and Support System (ENCOMPASS) during BIO 911 and other exercises for command and control of biological warfare incidents.

(U) **FY1999 Plans:**

- Anti-Virals/Immunizations. (\$ 17.500 Million)
  - Develop a modified stem cell, which can both detect and produce a prophylactic/therapeutic response to a pathogen (in cell culture).
  - Determine (in-vitro) toxicity of modified stem cell-produced therapeutics.
  - Create techniques to rapidly develop immunization strategies against bacterial and viral pathogens and toxins.
- Anti-Bacterials/Anti-Toxins. (\$ 15.000 Million)
  - Develop and test (in-vitro) cellular platforms for toxin destruction and toxin binding decoys.
  - Demonstrate selected strategies (in cell culture) to:
    - Inhibit the expression of disease causing (virulence) factors by pathogens.
    - Disrupt the disease causing (virulence) communications between pathogens.
    - Modulate the body's response to the presence of a pathogen.
- Multi-Purpose. (\$ 12.500 Million)
  - Define animal models in which to test the efficacy of modified stem cells to prevent disease.
  - Demonstrate in laboratory animals the efficacy of modified red blood cells to eliminate pathogens from the blood for the purpose of potential defense against biological warfare (BW) agents.
  - Determine pathogen detection and elimination efficacy for modified red blood cells with enzymes or other active molecules attached to their surfaces.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01	September 1998

- External Protection. (\$ 8.000 Million)
  - Develop polymeric materials for pathogen protection.
  - Develop a nonspecific surfactant agent to neutralize biological threat agents.
- Advanced Diagnostics. (\$ 12.000 Million)
  - Determine appropriate bodily sample types (blood, saliva, sputum, etc.) to use for diagnosis.
  - Determine which non-BW pathogens must be screened against because they mimic early symptoms of known biological warfare threat agents.
  - Begin identification of probes to be used in diagnosis systems.
  - Evaluate the feasibility of novel technologies and sampling strategies, such as detecting bodily responses indicative of infection.
- Sensors. (\$ 15.000 Million)
  - Continue development of air sampling technology for airborne biological materials.
  - Determine chemotaxonomic biomarkers for selected viral substances for detection in the mass spectrometer.
  - Demonstrate replacement of a surface-bound antibody with a "designer" small molecule for high affinity pathogen capture.
  - Complete Up-Converting Phosphors (UCP) detection system and field test.
  - Modify the prototype of a miniature biotetection system following Dugway Proving Ground test results.
  - Select cell and tissue types for the development of tissue based sensors.
  - Examine and select strategies to stabilize cell systems for long-term shelf life and functional response.
  - Demonstrate the ability to modify the duty cycle of a cellular response in single cell and tissue based sensors.
  - Demonstrate performance of a single cell sensor.
- Consequence Management. (\$ 8.000 Million)
  - Develop software toolkit for Enhanced Consequence Management Planning and Support System (ENCOMPASS).
  - Perform additional field tests of biological warfare (BW) defense attack response planning tool and electronic watchboard.
  - Develop electronic watchboard architecture.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01	September 1998

- Develop BW incident playbook authoring and maintenance tools.
  - Transition BW Medical Readiness Indicators to the Services.
- (U) **FY2000 Plans:**
- Anti-Virals/Immunizations. (\$ 20.000 Million)
    - Identify bacteriophage nucleic acids with potential for immunomodulatory activity against multiple viruses.
    - Demonstrate (in-vivo) the efficacy of anti-viral peptides derived from hematopoietic stem cells.
    - Develop a method of mucosal immunization based upon high level expression of pathogen antigens and epithelial transport molecules in transgenic plant cells.
    - Develop technologies for rapid design and development of new vaccines against novel pathogens.
  - Anti-Bacterials/Anti-Toxins. (\$ 17.800 Million)
    - Demonstrate (in-vivo) toxin-blocking antibodies and toxin binding decoys.
    - Demonstrate (in-vitro) the efficacy of a broad-spectrum pathogen antagonist.
    - Use gene-shuffling techniques to produce molecules to be screened for superantigenic properties.
    - Develop (in-vitro) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.
  - Multi-Purpose. (\$ 21.000 Million)
    - Explore concepts for therapeutics against bioregulators and other mid-spectrum agents.
    - Identify primary harmful immune responses to biological warfare agents.
    - Explore concepts for optimizing human immune response to biological warfare agents, minimizing negative sequelae.
    - Demonstrate in laboratory animal models the ability of modified stem cells to prevent disease.
    - Develop synthetic polymer complements for pathogenic antigens and virulence factors.
    - Identify monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
    - Identify polyvalent inhibitors for inhibiting pathogens on the surface of target cells in vivo.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY		R-1 ITEM NOMENCLATURE	
RDT&E, Defense-wide		Biological Warfare Defense	
BA2 Applied Research		PE 0602383E, Project BW-01	

September 1998

- External Protection. (\$ 18.500 Million)
  - Develop decoy molecules that will prevent the adhesion of multiple pathogenic toxins or viruses in vivo.
  - Demonstrate (in-vivo) a non-specific surfactant agent to neutralize biological threat agents.
  - Determine the capability for biochemical decontamination of surfaces via secretion/dispersion from micromachined surface orifices.
  - Demonstrate initial performance of a prototype device for the purification of water contaminated with biological warfare agent simulants.
  - Explore high throughput methods for the purification of contaminated air.
- Advanced Diagnostics. (\$ 22.000 Million)
  - Continue identification of probes to be used in diagnosis systems, and begin testing of probe panels in the laboratory.
  - Develop sample preparation techniques to optimize speed, accuracy, and reliability of diagnosis.
  - Identify one or more promising strategies for rapid detection based on bodily responses or other biomarkers to provide early indication of infection or exposure.
  - Explore concepts for diagnostic systems that can be upgraded rapidly (<10 minutes) in the field when new BW agents are identified as threats.
  - Determine range of cytokine levels in the healthy body verses an infected body using laboratory animals and cell cultures as models.
  - Determine feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
  - Determine feasibility of rapid single molecule DNA sequencing for accelerated patient diagnosis.
  - Explore concepts for diagnosing patients for bio-regulator and other mid-spectrum agent attack.
- Sensors. (\$ 36.700 Million)
  - Complete, test, and verify first-generation prototype of live agent biochip sensor.
  - Complete development of air sampling technology for airborne biological material.
  - Continue development of effective and rapid chip-reading capability with enhanced sensitivity.
  - Continue the development of unique signatures for bio-agents in mass spectrometry identification.
  - Develop biosensor technology for next-generation (bioengineered) threat agents.
  - Develop methods for identifying bioregulator-based BW agents.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01	September 1998

- Evaluate chemical clues used by biological systems in normal hunting strategies to revector the biological systems to search for BW agent production or storage.
- Explore options (e.g., training, genetic engineering, etc.) for the use of invertebrates in the detection of biological warfare agents and associated chemicals.
- Construct cell and tissue engineered configurations to enhance optical or electrical signal output from the sensor.
- Optimize electronic interfaces for optical and electrical reporting from cell and tissue based sensors.
- Investigate optimal system designs for deployment of a single cell and tissue based biosensor, which incorporate environmental sampling, microfluidics, and automated detection.
- Evaluate cell and tissue based informatics from temporal and spatial signals in cell and tissue sensor.
- Genetic Sequencing of Biological Warfare Agents. (\$ 4.000 Million)
  - Develop inventory of DoD-relevant biological warfare agent pathogens requiring sequencing.
  - Determine best methods for rapidly sequencing biological warfare pathogens and related species and strains.
  - Begin development of database mining techniques to find new targets for sensors, diagnostics, and therapeutics.
- Consequence Management (\$ 8.500 Million)
  - Develop distributed BW consequence management smart checklists for automatic pull and push of required information.
  - Continue development of ENCOMPASS software toolkit.
  - Continue development of playbooks and incorporate Incident Command System capabilities.
  - Demonstrate use of ENCOMPASS for OCONUS air base force protection against BW attack.
  - Demonstrate use of playbooks and automated checklists for training BW incident responders.

(U) **FY2001 Plans:**

- Anti-Virals/Immunizations. (\$ 21.500 Million)
  - Demonstrate the use of bacteriophage nucleic acids as immunomodulators against multiple viruses.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01	September 1998

- Validate (in-vivo) a method of mucosal immunization based upon high level expression of pathogen antigens and epithelial transport molecules in transgenic plant cells.
- Test and validate (in-vivo) the protective efficacy of vaccines and antibodies produced by plant cells against pathogens.
- Demonstrate the efficacy of the rapid and efficient delivery of pathogen antigens via new genetic vaccine vectors.
- Anti-Bacterials/Anti-Toxins. (\$ 19,500 Million)
  - Demonstrate surface expression of specific enzyme molecules for the rapid inactivation of various pathogens.
  - Demonstrate (in-vivo) the efficacy of a broad-spectrum bacterial pathogen antagonist.
  - Validate (in-vivo) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.
- Multi-Purpose. (\$ 23,000 Million)
  - Develop therapeutic strategies against bioregulators and other mid-spectrum agents.
  - Demonstrate synthetic polymer complements for pathogenic antigens and virulence factors.
  - Develop therapeutic strategies for minimizing harmful immune responses to biological warfare agents.
  - Demonstrate (in-vitro) the efficacy of monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
  - Validate polyvalent inhibitors for blocking pathogens on the surface of target cells in vivo.
  - Identify superantigens for broad protection against biological warfare agents with minimal side effects.
- External Protection. (\$ 21,000 Million)
  - Develop a novel architectural approach for the manufacture of materials that are effective in blocking pathogens and limiting disease.
  - Demonstrate a non-aqueous advanced decontamination method.
  - Demonstrate scalability of a water purification system effective against a range of biological agents (including toxins and bioregulators).
  - Build and test a prototype air purification system for individual soldiers.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01	September 1998

- Advanced Diagnostics. (\$ 22.000 Million)
  - Demonstrate that sample collection and/or preparation techniques do not introduce artifacts.
  - Test probe panels in relevant sample types.
  - Test, in model systems, one or more of the most promising candidate strategies for rapid detection based on bodily responses or other biomarkers to provide early indication of infection or exposure.
  - Develop methods for the rapid field upgrade of diagnostic systems with new threat probes.
  - Develop the capability to diagnose exposure to bio-regulator and mid-spectrum agents.
  - Demonstrate, in the laboratory, the feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
  - Evaluate the feasibility of additional strategies for direct identification or detection of infection without direct sample collection.
  - Demonstrate the ability to perform accelerated patient diagnosis using a rapid single molecule DNA sequencing technique in a model system.
- Sensors. (\$ 34.000 Million)
  - Continue the development of effective and rapid chip-reading capability with enhanced sensitivity and low false alarm rate.
  - Continue the development of advanced alternative technologies for live vs. dead bio-agent identification using peptides and other molecules.
  - Evaluate methods for removing micro-encapsulation of disguised pathogens and/or sensing through the micro-encapsulation.
  - Continue the development of technologies required for next-generation miniature biological detectors including the use of microelectromechanical systems (MEMS), microfluidics, and mesoscopic-sized components.
  - Evaluate false positive and false negative rates for systems of detectors.
  - Exploit and/or mimic the olfactory sensors of biological systems for use in the detection of biological warfare agents.
  - Engineer a deployable prototype cell and tissue sensor for field-testing.
  - Demonstrate enhanced signal output from engineered cells and tissue based sensors.
  - Integrate information from cell and tissue sensors with user interfaces for predictive responses.
  - Develop concepts for sensors capable of detecting biological warfare agent production in underground facilities.
  - Investigate critical design parameters for advanced biologically based BW sensor.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01	September 1998

- Genetic Sequencing of Biological Warfare Agents. (\$ 1.500 Million)
  - Continue development of database mining techniques and test on a subset of pathogenic genomes.
  - Transition sequencing activity to Department of Energy funding.
- Consequence Management (\$8.500 Million)
  - Demonstrate rapid construction and distribution of specific BW smart checklists for multiple responders.
  - Demonstrate ENCOMPASS management of multi-site BW incidents.
  - Demonstrate automatic construction of incident- and responder-specific playbooks and electronic watchboards.
  - Demonstrate use of ENCOMPASS for CONUS air base force protection against BW attacks.
  - Transition ENCOMPASS to National Guard Rapid Assessment and Initial Detection Units and to AF Theater Battle Management Core.

(U) Program Change Summary: (In Millions)

	<u>FY1998</u>	<u>FY1999</u>	<u>FY2000</u>	<u>FY2001</u>
Previous President's Budget	60.805	88.000	77.300	74.000
Current Budget	58.452	88.000	148.500	151.000

(U) Change Summary Explanation:

FY 1998 Decrease reflects SBIR reprogramming and minor program repricing.  
 FY 1999 PDM-directed increase has not been reflected in this submission.  
 FY 2000/01 Increases reflect PDM-directed expansion of biological warfare efforts in the following areas: biological agent detectors; enhanced medical diagnostics and therapeutics; air and water purification technologies; and genetic sequencing of biological warfare agents.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E, Project BW-01	September 1998

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost	
Total Program Element (PE) Cost	140,997	188,995	139,703	150,597	199,658	240,734	256,734	270,734	Continuing	Continuing	
Naval Warfare Technology TT-03	17,957	15,596	14,053	14,172	27,172	27,172	27,172	27,172	Continuing	Continuing	
Advanced Land Systems Technology TT-04	20,330	47,700	45,750	46,686	55,686	60,886	60,886	60,886	Continuing	Continuing	
Advanced Targeting Technology TT-05	0	0	0	0	10,000	38,300	48,300	58,300	Continuing	Continuing	
Advanced Tactical Technology TT-06	53,100	60,034	23,267	25,728	31,800	48,728	48,728	48,728	Continuing	Continuing	
Aeronautics Technology TT-07	19,135	34,000	36,000	44,011	45,000	45,648	51,648	55,648	Continuing	Continuing	
Advanced Logistics Technology TT-10	20,685	21,665	10,633	10,000	20,000	20,000	20,000	20,000	Continuing	Continuing	
Joint Logistics ACTD TT-11	9,790	10,000	10,000	10,000	10,000	0	0	0	0	N/A	

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology program element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Advanced Targeting, Advanced Tactical, Aeronautics, and Advanced Logistics technologies.

(U) The Naval Warfare Technology project is focusing on: Command, Control, Communications and, Intelligence/Synthetic Environments (C3I/SE), Digital Terrain Mapping, High Energy Density Materials, Large Payload Submarine, and Submerged Gun. In the C3I/SE program, advanced information technologies are being integrated into advanced prototype systems to provide improved battlefield awareness and dominance

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to mobile command centers in the field. Digital Mapping efforts are focused on demonstrating a lightweight, broadband phased-array antenna and altitude measuring system that will produce real-time 3D maps of littoral environments. The High Energy Density Materials program is exploring high risk/high pay-off breakthroughs in missile propellants and explosives technologies. The Large Payload Submarine effort will explore submersible platforms designed to maximize payload capacity. The Submerged Gun program will explore recent advanced gun technologies and high speed underwater flight to develop a submergible gun artillery capability.

(U) The Advanced Land Systems Technology project is developing technologies for contingency missions, mine clearing, and anti-personnel landmine alternatives to make U.S. combat forces more deployable, effective, survivable, and affordable. The SLID program will develop and test a system for providing protection against missiles and projectiles with explosive warheads. The Advanced Fire Support Systems program will provide rapid response and lethality associated with gun and missile artillery, thereby increasing survivability, yet requiring fewer personnel and less logistical support. The Counter-artillery Force Protection program will explore advanced sensors, munitions and deployment concepts to counter evolving threats. The Dog's Nose/Unexploded Ordnance Detection program will develop sensors for the chemically specific detection of explosives or other chemicals, comparable to the effectiveness of canine olfaction detection. The Glass Turret program will address vehicle survivability and targeting functions, for future combat vehicles. The Rapid Combat Insertion program will develop systems for the rapid high survivability insertion of material. The Alternatives to Antipersonnel Landmines program will explore technologies to obviate the need for mines.

(U) The Advanced Tactical Technology project is exploring the application of compact lasers; compact high-density holographic data storage and high performance computational algorithms to enhance performance of radars, sensors, communications, and electronic warfare and target recognition and tracking systems. In addition, the project funds technologies which focus on precision optics components for critical DoD applications, tactical landing systems, miniature air-launched decoy systems, affordable rapid response missile demonstrations, and a variable diameter tilt rotor.

(U) The Aeronautics Technology project will develop and demonstrate a new family of Micro-Aerial Vehicles (MAVs). The MAVs will be an order of magnitude smaller than any operational UAV and will be useful in a wide variety of military missions from covert imaging and chemical/biological agent detection to communication enhancement. The Micro Adaptive Flow Control effort, vertical take-off and landing unmanned air vehicle, and small-scale propulsion system concepts are also funded within this project.

(U) The Advanced Logistics project is investigating and demonstrating technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment materiel to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently.

(U) The Joint Logistics Advanced Concepts Technology Demonstration (ACTD) is a program that will provide hands-on demonstrations of existing and evolving logistics tools to facilitate their introduction into the service logistics community. Initial efforts will integrate existing tools that exploit near-term capabilities that can operate within the Global Combat Support System. Focus areas for the Joint Logistics ACTD correspond to Commander-In-Chief (CINC) and Service requirements to develop Joint Decision Support Tools (JDST).

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(U)	<u>Program Change Summary: (In Millions)</u>			
	<u>FY1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>
	148.331	188.995	186.619	212.597
Previous President's Budget				
Current Budget	140.997	188.995	139.703	150.597

(U) Change Summary Explanation:

FY 1998      Decrease reflects transfer of Facial Recognition Technology Program to SOLIC (\$2.8 M); transfer of Simulation Based Design Program to DLA (\$2.8M); SBIR reprogramming; inflation savings reduction; and minor program repricing.

FY 2000/2001      Reductions reflect completion of the Miniature Air Launched Decoy and the Affordable Rapid Response Missile programs in Project TT-06 and the transfer of Canard Rotor/Wing (CRW) and A160 efforts from Project TT-07 to PE 0603285E.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-03						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Naval Warfare Technology TT-03	17,957	15,596	14,053	14,172	27,172	27,172	27,172	27,172	Continuing	Continuing	

(U) Mission Description:

(U) The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. The enabling technologies include: Command, Control, Communications, and Intelligence/Synthetic Environments (C3I/SE) for littoral warfare; all weather interferometric sensor technology for precision 3-D terrain height estimation and surveillance of littoral environment for smart Naval Fire Support (NFS) weapons; investigations into High Energy Density Materials (HEDM) for advanced explosives and propellants; and innovative design concepts for expanding the envelope of operational capabilities for submersible platforms.

(U) In the Command, Control, Communication, and Intelligence/Synthetic Environment (C3I/SE) area, advanced information technologies are being integrated and applied to provide improved battlefield awareness and battlefield dominance to mobile command centers in the field (e.g., Force Commanders, Commander Joint Task Force (CJTF), and deployed Joint Special Operations Task Force (JSOTF) Commanders). The advanced prototype systems developed under this program integrate the latest technologies in high-bandwidth communications, object oriented information system, collaborative planning, intelligent database access, image processing, data exploitation, and high performance computing to address the unique (quick reaction and real-time execution) requirements of forward deployed, mobile commanders. The program developed systems design for collaborative crisis understanding and mitigation, developing tools and systems necessary to recognize, understand, forecast, and defuse potential crisis situations. Project Genoa will substantially reduce the time necessary to form teams, analyze crisis data, and develop and brief response options. This effort is focused on the commanders from the National Command Authority to the commanders of the unified commands.

(U) 3-D High-Resolution Digital Terrain Mapping will support the Naval Fire Support (NFS) missions in the littoral environment by development of advanced 3-D radar technologies which will enable the Commander Joint Task Force (CJTF) to obtain precise, near-real time 3-D maps of littoral environments. These precision 3-D maps provide accurate position information of all objects in the littoral theater and will be required for next generation smart munitions and surveillance systems. All weather interferometric sensors for precision 3-D terrain height estimation and surveillance of littoral environment will require the development of precision position and velocity measurement systems using inertial navigation systems tightly coupled with space based precision frequency and time sources. This effort will also develop and demonstrate

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R-1 ITEM NOMENCLATURE Tactical Technology		
		PE 0602702E, Project TT-03

advanced radar imaging techniques and processing algorithms required for precision geolocation by standoff sensors, particularly error reduction by multi-scene fusion, and optimal resource allocation using dynamic programming.

(U) The High Energy Density Materials (HEDM) program fosters high-risk/high payoff efforts that could result in major breakthroughs in missile propellant and explosives technologies applicable to a wide variety of tactical and strategic military systems. The HEDM project will investigate the synthesis of new molecules capable of providing orders of magnitude increases in explosive and/or propulsive energy per unit weight. The stability and energy content of several such molecules have been predicted theoretically. The molecules will contain only nitrogen atoms or a very high percentage of nitrogen atoms, a situation that makes their production and use environmentally friendly. The potential benefits include: thermodynamic properties which could result in their having two-to-six times as much propulsive/explosive energy as current state-of-the-art operational materials, the "greening" of production and use, and reduction of detectability. Missile systems with size constraints could have increased range, maneuverability for flexible targeting, and/or increased kill effectiveness due to improvements in both the propellant's thrust and the warhead's lethality (per weight and volume). The program builds on theoretical work previously sponsored by other DoD organizations and provide some high risk excursions into materials which are theoretically possible but for which there is no currently known defined synthetic route.

(U) Current submarine designs are significantly limited in the quantity and types of payloads that can be accommodated. Recently completed high level studies have highlighted the critical need to address these limitations if the stealth inherently available to submerged platforms is to remain tactically relevant in the future. The Large Payload Submarine (LPS) study is intended to explore the operational and technical challenges and opportunities posed by submersible platforms designed specifically for the objective of maximizing payload capacity and variety. Implications to the design of the platform, associated combat systems, and supporting ordnance will be considered.

(U) The Submerged Gun program will build on recent advances in advanced gun technology (such as advanced propellant and rail gun concepts) and high-speed underwater flight (i.e., super-cavitation) for the purpose of enabling a gun artillery system capable of being operated from a submerged condition. If technologically feasible, the concept possesses a number of attractive warfighting characteristics. From a naval perspective, such a system would enable high kinetic energy weaponry to be submarine-mounted, greatly enhancing the effectiveness of submarines to conduct shore fire support while simultaneously enhancing the stealth and survivability of the gun. From a military perspective, it would enable the placement of artillery in rivers, lakes, and ponds, significantly improving survivability by complicating the counter-battery targeting and attack problem. There is some opportunity that such a technology concept might ultimately enable an additional layer of missile defense by allowing attack of outgoing ballistic missiles from secure, covert positions at time of launch.



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- (U) Program Accomplishments and Plans:
- (U) FY1998 Accomplishments:
- Continued systems development and initiated development of a tool for rapid, collaborative option development, evaluation, and presentation; demonstrated and evaluated retrieval agents; demonstrated use of access templates and profiles; evaluated filters. Demonstrated the ability to navigate several of the most important, crisis-related databases for acquiring information on a simulated crisis. (\$ 3.200 Million)
  - Evaluated ability to quantify centers-of-gravity and pressure points for option development, and demonstrated modeling capabilities at Joint Task Force ATD/Global Command and Control System Insertions. Demonstrated crisis presentation capability for prioritizing policy and plans at National Security Council/National Military Command Center and supporting intelligence agencies. (\$ 4.419 Million)
  - Demonstrated production of Digital Terrain Elevation Data (DTED) near level 5 accuracy using multiscene Interferometric Synthetic Aperture Radar (IFSAR) and LIDAR fusion, and interwoven SAR/Ground Moving Target Indicator (GMTI) tasking. (\$ 1.600 Million)
  - High Energy Density Materials (HEDM): Initiated focused synthesis; established parallel supporting efforts in theoretical chemistry, kinetics and thermodynamics. (\$ 2.080 Million)
  - The following activity was funded by Congressional addition to the FY 1998 President's Budget:
    - Center of Excellence for Research in Ocean Sciences (CEROS) - Continued most promising ocean science efforts at the CEROS. (\$ 6.658 Million)
- (U) FY1999 Plans:
- Demonstrate initial operational capability of the data retrieval and visualization capability, initial operational capability of the crisis modeling capability, and begin installation of modeling capability and integration with data retrieval capability at CINCPAC and DIA. Begin installation and integration of advanced presentation capability. Project Genoa is beginning transition to the advanced technology stage and is moving into PE 060370E, Command Control and Information Systems Project CCC-01. (\$ 7.034 Million)

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- Continue development of synthesis pathways and theoretical chemistry support activities for High Energy Density Materials (HEDM); investigate methods to scale-up successful synthetic routes to production quantities. (\$ 2.250 Million)
  - Commence utility, feasibility and performance studies of large payload submarine options, including approaches for expanded ordnance, approaches for deployment of distributed sensors for use in preparation of the networked battlespace of future, and approaches for the support of small submersible platforms. (\$ 5.000 Million)
  - Conduct feasibility study of gun system designed to operate from a submerged condition. (\$ 1.312 Million)
- (U) **FY2000 Plans:**
- Scale up synthesis of High Energy Density Materials (HEDM) to gram quantities and experimentally verify physical properties. (\$ 5.253 Million)
  - Complete initial Large Payload Submarine (LPS) concept studies; identify potential supporting technology risks and opportunities. (\$ 3.250 Million)
  - Conduct component technology development to support a submerged gun; complete proof-of-concept testing. (\$ 5.550 Million)
- (U) **FY2001 Plans:**
- Continue High Energy Density Materials (HEDM) development and physical property verification; assess HEDM system applications. (\$ 4.975 Million)
  - Commence large payload submarine supporting technology development effort to mature most promising technology opportunities. (\$ 4.150 Million)
  - Commence design and fabrication of an initial submerged gun test article. (\$ 5.047 Million)

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(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Advanced Land Systems Technology TT-04	20,330	47,700	45,750	46,686	55,686	60,886	60,886	60,886	Continuing	Continuing	

(U) Mission Description:

(U) This project is developing technologies for contingency missions and military Operations-Other-Than-War (OOTW) to make U.S. combat forces more deployable, effective, survivable, and affordable. This project supports seven main efforts: Small Low-Cost Interceptor Device (SLID); Advanced Fire Support Systems; Counter-artillery Force Protection (CFP); Dog's Nose/Unexploded Ordnance Detection; Alternatives to Antipersonnel Landmines; Glass Turret (GT); and Rapid Combat Insertion (RCI).

(U) The SLID program is developing and testing a system, which protects threatened systems against missiles and projectiles with explosive warheads. This system will detect, track and intercept threats such as anti-armor missiles, mortars, artillery, and top-attack sensor fused munitions at a standoff distance sufficient to render them ineffective. Applications for the SLID system include: self-defense of vehicles; defense of high value fixed sites such as command centers, parked aircraft and radars; and, with further development, naval platforms and low-speed aircraft.

(U) The Advanced Fire Support Systems program will develop and test containerized, platform independent land attack weapon systems. These systems will provide rapid response and lethality in packages requiring significantly fewer personnel, decreased logistical support, lower life-cycle costs, and with increased survivability compared to current gun and missile artillery. These systems will allow the military to more completely capitalize on recent advances in military doctrine and infrastructure, such as the ongoing digitization of the Army. The program will develop and demonstrate highly flexible systems including a guided projectile/munition, a remotely commanded self-locating launcher, and a command and control system compatible with military doctrine.

(U) The Counter-artillery Force Protection (CFP) program will develop concepts for defending forces and civilian enclaves against air threats including high rate of fire missile artillery carrying submunitions. The program will explore advanced sensors, munitions and deployment concepts to counter this evolving threat. System concepts will be developed and analyzed.

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(U) The Dog's Nose/Unexploded Ordnance (UXO) Detection program will develop sensors for the chemically specific detection of explosives or other chemicals characteristic of land mines and/or shallowly buried UXOs. The sensors developed under this program will provide soldiers with the effectiveness of canine olfaction detection without the logistics and other constraints imposed by the use of live animals. These chemically specific sensors will work either singly or in conjunction with other technologies such as the hyperspectral mine detector, developed under the Small Unit Operations (SUO) program that exploit different physical features.

(U) DARPA will develop technologies that provide alternatives to antipersonnel landmines (APL). The systems developed under this program will provide our warfighters with enhanced capabilities that obviate the need for mines. Technologies considered include: Self-healing anti-tank (AT) minefields (that allow the protection of AT mines without the use of APL), tags with minimally guided munitions that allow the compression of critical timelines and distance constraints imposed by conventional indirect and direct fire approaches, and advanced spoofing concepts that will permit sophisticated battlefield shaping capabilities.

(U) The Glass Turret (GT) program will be an integrated sensor system, which performs both vehicle survivability and targeting functions for future combat vehicles. The program will take radar and electro optic technologies developed under the SLID program and extend its capabilities to include other required functions, such as reconnaissance, surveillance and targeting. The program will also address display systems and human factors. Particular attention will be placed on minimization of signatures from both active and passive sensors.

(U) The Rapid Combat Insertion (RCI) program will develop systems for the rapid, high survivability insertion of material and, in principle, personnel. The systems would be deployed from aircraft at safe distance from the desired delivery point and would deliver their contents to precise locations. The program will look to significantly increase range, speed, payload, and survivability over current parachute and parafoil based systems.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Small Low-Cost Interceptor Device (SLID). (\$ 6.601 Million)  
– Completed development leading to live-on-live Small Low-Cost Interceptor Device (SLID) testing.

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- Unexploded Ordnance Detection. (\$ 10.729 Million)
  - Demonstrated laboratory scale system for chemically specific detection of land mines.
- Advanced Fire Support System (AFSS). (\$ 3.000 Million)
  - Conducted initial activities in the Advanced Fire Support System development.
  - Conducted concept and requirements analysis for platform independent and unmanned missile artillery packages.
  - Developed baseline concept designs.

(U) FY1999 Plans:

- Small Low-Cost Interceptor Device (SLID). (\$ 6.500 Million)
  - Complete vehicle self-protection testing.
  - Transition ground vehicle active protection technology to Army.
  - Develop active and passive survivability capabilities against unitary munitions for both vehicle and ground forces, including extension of SLID protection range for application to high value fixed sites.
- Unexploded Ordnance Detection. (\$ 11.200 Million)
  - Field demonstration of prototype chemically specific land mine detector paired with other sensors as appropriate.
- Advanced Fire Support System (AFSS). (\$ 8.000 Million)
  - Develop detailed designs for the Advanced Fire Support System architecture.
  - Conduct evaluations and testing of high risk and critical components.
  - Define system demonstration objectives.
- Counter-artillery Force Protection (CFP). (\$ 5.000 Million)
  - Define one or more system architectures, including sensors, munitions and deployment, to meet the mission needs for enclave protection against missile artillery.

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- Alternatives to Antipersonnel Landmines. (\$ 17.000 Million)
  - Develop technologies that obviate the military missions served by antipersonnel landmines.
  - Investigate system design issues for self-healing antitank landmines including distributed communications and propulsion mechanisms.
  - Analyze parameters for tagging individuals for tags and minimally guided munitions concept.
  - Begin artificial image creation work for advanced spoofing concepts.

(U) FY2000 Plans:

- Advanced Fire Support System (AFSS). (\$ 22.750 Million)
  - Complete detail design for AFSS objective demonstration system, including launch, fire control, and each of the demonstration flight systems.
  - Develop and test component hardware and software for AFSS.
  - Initiate hardware-in-the-loop tests.
  - Plan and initiate limited objective flight tests.

- Alternatives to Antipersonnel Landmines. (\$ 23.000 Million)
  - Initial demonstration of self-healing antitank mines – individual mine movements and communication among several mines.
  - Demonstrate tagging concepts in the laboratory.
  - Early demonstration of small-scale artificial image creation for advanced spoofing concepts.

(U) FY2001 Plans:

- Advanced Fire Support System (AFSS). (\$ 12.000 Million)
  - Complete system hardware and software development.
  - Complete limited objective flight tests.
  - Plan and initiate preparations for full system demonstrations.
- Alternatives to Antipersonnel Landmines. (\$ 22.000 Million)
  - Field demonstration of self-healing antitank minefield.

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- Demonstrate tags in the field with appropriate wake-up and guidance signals transmitted to minimally guided munitions.
- Down-select advanced spoofing concepts and initiate small scale prototype investigations.

- Glass Turret (GT). (\$ 6.686 Million)
- Begin development of integrated radar and electro optic suite.
  - Begin development of integrated display system.

- Rapid Combat Insertion (RCI). (\$ 6.000 Million)
  - Begin development of material insertion system.
  - Define and develop concepts for personnel insertion systems.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide BA2 Applied Research					Tactical Technology PE 0602702E, Project TT-06						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Advanced Tactical Technology TT-06	53,100	60,034	23,267	25,728	31,800	48,728	48,728	48,728	Continuing	Continuing	

(U) Mission Description:

(U) This project focuses on seven broad technology areas: (a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, sensors, and high-power applications; (b) compact high density holographic data storage for high bandwidth image processing and access to large data bases; (c) high performance computational algorithms for signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; (d) precision optics components for critical DoD applications; (e) miniature air-launched decoy systems; (f) an affordable rapid response missile demonstration; and (g) a variable diameter tilt rotor.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Compact Lasers. (\$ 2.271 Million)
  - Demonstrated compact high power tunable lasers and laser diodes at mid-infrared wavelengths.
  - Developed breadboard tunable mid-infrared lasers for closed-loop infrared countermeasures.
- Holographic Data Storage. (\$ 3.294 Million)
  - Demonstrated 1 terabit storage capacity for functional evaluation of holographic data storage systems.
- High Performance Algorithm Development. (\$ 11.219 Million)
  - Implemented a hybrid automatic target recognition strategy for synthetic aperture radar exploiting most advantageous features of wavelets and nonlinear partial differential equation-based methods.
  - Developed application-specific wavelet-based automatic target recognition algorithms.

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	PE 0602702E, Project TT-06		

- Continued development of most promising strategies for data, sensor, and algorithm fusion that exploit the feature extraction capability of wavelets with applications to signal and image processing.
- Developed prototype electromagnetic scattering models for objects in ground clutter.
- Demonstrated toolboxes for generating optimal portable Fast Fourier Transforms and wavelet algorithms; and applied to high dimensional synthetic aperture radar.
- Developed mathematical approaches to creating optimal portable applications libraries for selected computational kernels required in thin film process simulations and signal processing applications.
- Advanced Mathematics for Microstructural Process Control. (\$ 6.213 Million)
  - Developed physicochemical models for thin film vapor deposition process that integrate process, sensing, and control considerations and provide understanding of critical microstructure issues needed to design high-quality and high yield manufacturing processes.
  - Implemented fast algorithms for modeling and design of large-scale, high-performance electronics circuits.
  - Developed reduced order physicochemical models and algorithms for real-time sensing and control of thin film vapor deposition processes.
- Precision Optics Technology. (\$ 4.832 Million)
  - Continued development of conformal optical system components for tactical systems.
  - Completed designs of conformal optics sensor systems and down selected demonstration candidate from airborne platforms or missiles.
  - Fabricated aspheric optical components and diffractive optical elements on curved substrates.
  - Demonstrated metrology tools.
- Miniature Air-Launched Decoy (MALD). (\$ 19.731 Million)
  - Fabricated and delivered flight-test vehicles.
  - Conducted flight readiness review.
  - Continued ground testing and initiated Development Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) flight-testing.

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- Began ground and flight maintenance training and began operational training.
- Initiated Seek Eagle process.
- Affordable Rapid Response Missile Demonstration (ARRMD). (\$ 5.540 Million)
  - Conducted missile concept development, including manufacturing process definition, propulsion integrated flowpath demonstration and manufacturing demonstration.
  - Defined flight-test plan.
  - Began affordability assessment.
  - Performed mission assessment.

(U) FY1999 Plans:

- Compact Lasers. (\$ 6.800 Million)
  - Demonstrate room temperature long wavelength laser diodes in the 7-to-9 micrometer wavelength range.
  - Complete demonstration of compact high power tunable lasers and lasers diodes at mid-infrared wavelength.
  - Develop packaged tunable mid-infrared lasers for airborne infrared countermeasures.
  - Complete demonstration of laser diode arrays operating at mid-infrared wavelengths.
- Holographic Data Storage. (\$ 1.700 Million)
  - Complete program with demonstration of holographic data storage for automatic target recognition and data warehouse applications.
- High Performance Algorithm Development. (\$ 15.873 Million)
  - Demonstrate hybrid automatic target recognition strategy for synthetic aperture radar exploiting the most advantageous features of wavelets and nonlinear partial differential equation-based methods.
  - Demonstrate application-specific wavelet-based automatic target recognition algorithms.
  - Validate prototype electromagnetic scattering models for objects in ground clutter.
  - Demonstrate data, sensor, and algorithm fusion algorithms for signal and image processing applications that exploit the features extraction capability of wavelets.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06	September 1998

- Demonstrate fast algorithms for electromagnetic scattering at subwavelength scales and off rough surfaces.
- Develop prototype toolboxes and compilation strategies for optimizing key computational kernels in Fast Fourier Transform algorithms.
- Develop algorithms for designing variable-precision filter for adaptive signal processing.
- Demonstrate feasibility of mathematical approaches to creating optimal portable applications libraries for selected computational kernels required in complex physical process simulations.
- Advanced Mathematics for Microstructural Process Control. (\$ 7.761 Million)
  - Develop morphological surface models for the deposition of giant magnetoresistive (GMR) films.
  - Develop algorithms for fundamental chemical calculations that allow treatment of larger systems and more extended phenomena in thin film deposition.
  - Develop multiresolution homogenization techniques to reduce systems of partial differential equations to equations amenable to process optimization and design of control algorithms.
  - Validate island dynamics mathematical model and level set methods for epitaxial growth.
  - Validate prototype reactor design for deposition of high temperature superconducting thin films.
- Precision Optics Technology. (\$ 6.900 Million)
  - Continue development of conformal optical systems components.
  - Demonstrate near net-shape growth of conformal windows.
  - Laboratory assembly, demonstration and test of conformal sensor system for missile applications.
- Miniature Air-Launched Decoy (MALD). (\$ 7.000 Million)
  - Continue operational demonstrations, acquire limited flight clearance (Seek Eagle) deliver 32 operational capable test assets and transition to Services.
  - Explore other concepts or low cost Miniature Air-Launched Decoy (MALD) airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, jamming, etc.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06.	September 1998

- Affordable Rapid Response Missile Demonstrator (ARRMD). (\$ 6.000 Million)
    - Complete propulsion integrated flowpath demonstration and manufacturability demonstration.
    - Perform unit cost analysis.
    - Conduct Warfighting Analysis Lab exercises.
  - Variable Diameter Tilt Rotor (VDTR). (\$ 5.000 Million)
    - Initiate preliminary design of prototype variable diameter rotor and lightweight transmission system.
  - Supersonic Low Cost Cruise Missile Interceptor (SSLCCMI). (\$ 3.000 Million)
    - Establish preliminary and final design after cost and performance trades. Determine seeker and turbine engine integration and configuration. Refine operational concepts and requirements.
- (U) **FY2000 Plans:**
- Compact Lasers. (\$ 3.000 Million)
    - Demonstrate mid- and long-wavelength infrared high power quantum cascade laser diode arrays operating at room temperature.
    - Develop side pump geometries for coupling diode laser arrays to fiber gain medium.
  - Precision Optics. (\$ 5.000 Million)
    - Complete assembly and test of conformal optics Stinger missile dome to quantify performance improvements.
    - Laboratory assembly and test of conformal optical system for airborne applications.
  - High Performance Algorithm Development. (\$ 11.057 Million)
    - Demonstrate feasibility of optimized portable application library generation approaches for key kernels used for signal processing.
    - Demonstrate utility of multiscale segmentation and registration algorithms in DoD automatic target recognition applications.
    - Develop high fidelity feature extraction algorithms for X-band high range resolution radar based on computational electromagnetic modeling.
    - Develop advanced mathematical algorithms for high throughput hyperspectral infrared imaging.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, TT-06	September 1998

- Validate fast algorithms for electromagnetic scattering at subwavelength scales and of rough surfaces.
- Develop codes for predicting antenna radiation patterns and scattering off of electrically large, smooth impenetrable bodies.
- Advanced Mathematics for Microstructural Process Control. (\$ 4.210 Million)
  - Validate morphological surface models for the deposition of giant magnetoresistive (GMR) films.
  - Develop models for the effects of using surfactants during the deposition of interfaces and on the resulting GMR ratio.
  - Construct and test control/optimization codes for sputtering and molecular beam epitaxy reactors.
  - Apply the island dynamics growth model to films of many monolayers.
  - Extend level set methodology to complex diffusion processes in thin film processing.
- (U) FY2001 Plans:
  - Compact Lasers. (\$ 3.400 Million)
    - Develop compact components for high peak power lasers -- fiber laser oscillator, pulse stretcher, amplifier, and compressor.
    - Develop core and cladding designs for single mode operation of high power fiber lasers for output power levels of 300 watts.
  - Precision Optics. (\$ 5.0 00 Million)
    - Complete assembly and test of a conformal optics sensor system on an airborne platform to quantify performance improvements.
  - High Performance Algorithm Development. (\$ 12.098 Million)
    - Demonstrate feasibility and portability of optimized portable application library generation approaches for a complete signal-processing algorithm.
    - Demonstrate benefits of variable precision filters on an adaptive computing platform.
    - Develop tool set implementing algorithmic, memory, and compilation models applied to a multipole test problem.
    - Demonstrate performance and portability of algorithms and application library generation approaches for selected computational kernels required in complex physical process simulations.
    - Develop algorithms for predicting antenna radiation patterns and scattering, both off of and through inhomogeneous materials deep cavities.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06	September 1998

- Advanced Mathematics for Microstructural Process Control. (\$ 5.230 Million)
  - Validate theoretical study of effects of using surfactants during deposition to improve interfaces and the giant magnetoresistive (GMR) ratio.
  - Demonstrate reduced kinetic/continuum models for describing the gas phase dynamics and the beam dynamics in a GMR thin film reactor.
  - Validate reduced order model and algorithms for sensing and control of thin film vapor deposition processes.
  - Demonstrate advanced molecular dynamics/accelerated molecular dynamics simulation techniques for the growth of multilayer materials.

(U) Other Program Funding Summary Cost: (In Millions)

	<u>FY 1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>	<u>FY 2003</u>	<u>FY 2004</u>	Cost to Complete	Total Cost
Funding for Miniature Air-Launched Decoy PE 0603750D, Advanced Concept Technology Demonstrations	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	361.1

(U) Schedule Profile: Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide BA2 Applied Research					Tactical Technology PE 0602702E, Project TT-07						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Aeronautics Technology TT-07	19,135	34,000	36,000	44,011	45,000	45,648	51,648	55,648	Continuing	Continuing	

(U) Mission Description:

(U) Aeronautics Technology efforts will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems or provide revolutionary new system capabilities for satisfying current and projected military mission requirements.

(U) A new family of Micro-Air Vehicles (MAVs) that are at least an order of magnitude smaller than current flying systems (less than 15 cm in any dimension) will be developed and demonstrated. The capability to accomplish unique military missions as diverse as covert imaging in constrained areas, biological-chemical agent detection and characterization, remote precision mines, and urban battlefield communications enhancement, will be stressed through an examination of a variety of vehicle concepts. The resulting capability should be especially beneficial in the emerging urban warfighting environment, characterized by its complex topologies, confined spaces and areas (often internal to buildings), and high civilian concentrations. The MAV program will focus on the technologies and components required to enable flight at these small scales, including flight control, propulsion and lightweight power, navigation and communications. These will build upon and exploit numerous DARPA technology development efforts, including advanced communications and information systems, high performance computer technology, Microelectro-mechanical Systems (MEMS), advanced sensors, lightweight, efficient high density power sources, and advanced electronic packaging technologies.

(U) Micro Adaptive Flow Control (MAFC) technologies enable control of large-scale aerodynamic flows using small scale actuators. MAFC technologies combine adaptive control strategies with advanced actuator concepts like micro-scale synthetic jets, MEMS-based microactuators, pulsed-blowing and smart structures to cause the delay or prevention of fluid flow separation. Originally conceived as low-power, adaptive flight controls for Micro Air Vehicles, MAFC technologies may also apply to larger systems such as adaptive lift-on-demand for agile missiles and uninhabited tactical aircraft, and low-drag, non-intrusive methods to aerodynamically steer projectiles for extended range and precision. Advanced flow control concepts will be explored in the context of system level performance benefits and cost assessments. MAFC technology evaluations will be made under system-relevant flow conditions, and the most promising approaches will be selected for component- or system-level demonstration.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-07		September 1998

(U) The Navy and the Marine Corps have a need for an affordable, survivable, vertical take-off and landing (VTOL) unmanned air vehicle (UAV) to support dispersed units in littoral and urban areas. The Defense Advanced Research Projects Agency (DARPA), in partnership with the Office of Naval Research (ONR) and industry, have formulated a program to explore two innovative new vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first concept is an advanced Canard Rotor/Wing (CRW) aircraft which offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. Detailed design, fabrication and flight test of this scaled vehicle concept will be conducted to validate the command and control, stability and control, propulsion system and aerodynamic performance required for vertical take-off, landing and hover via a rotating center wing which is stopped and locked in place for efficient high speed cruise. The second concept (A160), will exploit a hingeless, rigid, rotor concept to produce a VTOL UAV with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>2000 nm) and endurance (24-48 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability, maintainability and performance. This program will transition to PE 0603285E in FY00.

(U) A new, small-scale class of propulsion systems will be developed in the size range from 0.5 cm to 5.0 cm in diameter, with thrust levels from 10 g to 5.0 kg. They will enable future development of a new generation of very small weapons and military platforms including micro air vehicles, unmanned combat air vehicles (UCAVs), missiles and space launch vehicles. Radical new capabilities to be explored range from shirt-button-sized micro gas-turbine and micro rocket engines to 5 cm scale gas-turbine and pulse detonation engines (PDEs). Examples of new mission capabilities include delivery of micro satellites to low earth orbit (LEO), and light weight, affordable, extended range small scale precision munitions. These small-scale munitions would complement emerging unmanned vehicle systems and greatly increase mission capabilities by simultaneously increasing loadout, range and precision.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Micro Air Vehicles. (\$ 14.040 Million)
  - Conducted design and development of functionally diverse propelled Micro Air Vehicle (MAV) Systems, employing alternative technology solutions, and satisfying user-identified critical military applications. Identified and initiated development of key flight enabling technologies. Continued evaluation of operational MAV concepts.

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APPROPRIATION/BUDGET ACTIVITY		R-1 ITEM NOMENCLATURE	September 1998
RDT&E, Defense-wide BA2 Applied Research		Tactical Technology PE 0602702E, Project TT-07	

- Conducted studies of Micro Adaptive Flow Control (MAFC) technology feasibility in the context of selected system applications, including micro air vehicle flight controls and small scale aerodynamically steerable munitions, aspirated gas turbine compressors, inlet duct flow control, rotorcraft and tilt rotor vehicles. Initiated assessment of actuator effectiveness, scaling, and fabrication methodologies.
- Initiated system design, component tests, and flight control simulations for the Canard Rotor Wing and A160 vertical take-off and landing (VTOL) unmanned air vehicle (UAV) concepts. Completed major structural analysis effort to prove feasibility of main rotor system concept. Design of A160 main rotor blades, hub and main gearbox test components complete and released for bids and/or tooling. (\$ 5.095 Million)

(U) FY1999 Plans:

- Conduct Micro Air Vehicle (MAV) system development and fabrication. Continue exploration and demonstration of flight enabling technologies and subsystems. Initiate flight test planning for propelled rotary-wing and fixed-wing reconnaissance vehicle systems incorporating operational templates, design flight capabilities, and mission characteristics. Initiate advanced MAV concept definition. (\$ 13.000 Million)
- Conduct assessment of small-scale air-breathing and rocket propulsion systems for a new class of small-scale weapon systems and flight vehicles. Systems to be evaluated include micro-turbojet and micro-rocket engines, pulsed combustor engines, and miniature gas turbine and pulse-detonation engines. Initiate development of selected Small Scale Propulsion Systems. (\$ 2.000 Million)
- Complete studies of Micro Adaptive Flow Control (MAFC) feasibility for high work compressors, aerodynamically steerable munitions, and rotary and tilt wing hover vehicles. Initiate development and demonstration of MAFC actuator and controller technologies for system-relevant flow conditions. (\$ 7.000 Million)
- Complete detailed designs, analyses, simulations and component tests and begin fabrication of Canard Rotor Wing and A160 demonstrator aircraft. Conduct engineering, endurance and ground tests. Begin fabrication of two Canard Rotor/Wing (CRW) demonstrators and three A160 demonstrators. (\$ 12.000 Million)

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(U) FY2000 Plans:

- Complete development of flight enabling technologies for micro air vehicles. Complete flight demonstration of the hovering Micro Air Vehicle (MAV) system, and complete fabrication and flight test of the fixed wing MAV system. Continue concept of operations evaluation for military use. Begin design of advanced MAV flight demonstrator. (\$ 11.000 Million)
- Continue Micro Adaptive Flow Control (MAFC) actuator and controller development. Assess actuator and control system performance, control authority, bandwidth and power requirements. Integrate MAFC technology into feasibility demonstration systems for selected military applications, including high-work compressors, adaptive munitions, and fixed-and rotary wing air vehicles. (\$ 16.000 Million)
- Select several candidate small-scale propulsion system technologies for detailed design. Begin fabrication of selected small-scale propulsion systems. (\$ 9.000 Million)

(U) FY2001 Plans:

- Complete advanced MAV development including system fabrication and flight testing; complete military concept of operations evaluation and complete transition of MAV systems to services. (\$ 9.011 Million)
- Complete MAFC technology development and validation tests. Initiate studies to integrate MAFC technologies into full-scale engine, munition and aircraft systems. Initiate demonstration plan, including flight and field tests of integrated MAFC systems. (\$ 19.000 Million)
- Design and fabricate selected small-scale propulsion subsystems and fabricate integrated flight-ready propulsion system prototypes. Conduct subsystem checkout and initial system tests and demonstrations. (\$ 16.000 Million).

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(U) Other Program Funding Summary Cost:

FY 1998      \$5.6 Million of Defense Airborne Reconnaissance Office (DARO) funding provided for Canard Rotor Wing (CRW) concept demonstration.

(U) Schedule Profile:      Not Applicable.

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RDT&E, Defense-wide BA2 Applied Research					Tactical Technology PE 0602702E, Project TT-10						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Advanced Logistics Technology TT-10	20,685	21,665	10,633	10,000	20,000	20,000	20,000	20,000	Continuing	Continuing	

(U) Mission Description:

(U) The Advanced Logistics Project will investigate and demonstrate technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment material to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently than ever before. Currently, this is accomplished using isolated, independent, and sometimes incompatible systems, processes and data. Therefore, the very rapid replanning and redirection necessary to support missions involving simultaneous local and major regional conflicts cannot be accomplished today. The Advanced Logistics Project will address these shortcomings and enable this significant capability to be developed. In addition, the project has enormous potential for cost savings through greatly improved management of transportation and logistics assets.

(U) This project will develop automated, multi-echelon, collaborative logistical/transportation technologies that will provide warfighters with an unprecedented capability to monitor, rapidly replan, and execute the revised logistics plan as the situation requires, even while assets are enroute to the theater. The Advanced Logistics Project will focus on the following three areas: 1) Development of applications providing a technology environment that allows warfighters to rapidly understand and assess the logistics and transportation implications of a crisis situation, to generate effective plans and courses of action, to monitor a plan's execution and to use that information to re-plan; 2) Automated systems that will enable significant efficiency improvements in transportation and logistics, such as improving access to data, monitoring the condition and status of shipments, personnel, inventories, logistics assets and the infrastructure, the creation of "plan sentinels" to serve as an early warning system for plan deviations, and improved theater distribution; and 3) Development of a computer network infrastructure that allows distributed real-time visualization and interaction with all phases, elements and components of the military and commercial transportation infrastructure. The capabilities from these three areas will be integrated to demonstrate a prototype end-to-end system solution.

(U) The Advanced Logistics Project supports Joint Vision 2010, US Transportation Command and Defense Logistics Agency initiatives, and is coordinated with other related logistics efforts within the DoD. As these technologies mature, they will immediately transition to other

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joint initiatives which include the Defense Logistics Agency's Logistics Research and Development Demonstration (PE 0603712S), the Joint Logistics Advanced Concept Technology Demonstration (Project TT-11), and eventually to the Global Command and Control System (GCCS) and the Global Combat Support System.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Developed and demonstrated the automated generation of a portion of a logistics plan for a major force deployment from home station to the port of embarkation across a distributed environment involving 5 different locations. (\$ 7.700 Million)
- Initiated development of plan deviation detection sentinels and predictive analysis to assist in identification of replanning opportunities. (\$ 3.500 Million)
- Continued development of advanced software data collection techniques. Initiated development of a Dynamic Critical Items List for sustainment planning and execution. Continued development of multi-echelon collaborative logistical support technologies. (\$ 9.485 Million)

(U) FY1999 Plans:

- Demonstrate an integrated environment to support the planning, execution and monitoring of a unit deployment from point of debarkation through in-theater distribution, including automated infrastructure assessment and monitoring. (\$ 9.200 Million)
- Develop and demonstrate the ability to negotiate the exchange of information between suppliers and buyers, including rapid, flexible item and item relationship catalogs for automated sustainment processing. (\$ 5.000 Million)
- Develop automated deviation detection and triggering of the replanning processes. Continue development of a Dynamic Critical Items List for sustainment planning and execution. Develop and demonstrate automated medium grained course of action evaluation that is linked to the war plan. (\$ 7.465 Million)

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(U) **FY2000 Plans:**

- Develop capability to automatically plan and schedule movements from installation to the theater of operations and integrate the resulting movement plan with operations within the theater. Demonstrate capability for users to visualize multiple facts of the transportation schedule. (\$ 2.733 Million)
- Develop capability to dynamically manage stockage levels across multiple supply chain levels and, multiple echelons, services and agencies. (\$ 3.400 Million)
- Develop capability to automatically notify users when projected completion of an executing task differs from planned timeline. (\$ 4.500 Million)

(U) **FY2001 Plans:**

- Develop capability to automatically build and compare logistics plans in support of four operational courses of action in 4 hours. (\$ 6.400 Million)
- Develop capability to monitor resource information, availability, capacity, costs and to view past, present and projected logistical situations. (\$ 3.600 Million)

(U) **Other Program Funding Summary Cost:** Not Applicable.

(U) **Schedule Profile:** Not Applicable.

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RDT&E, Defense-wide BA2 Applied Research					Tactical Technology PE 0602702E, Project TT-11					September 1998
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Joint Logistics ACTD, TT-11	9,790	10,000	10,000	10,000	10,000	0	0	0	0	N/A

(U) Mission Description:

(U) The Joint Logistics Advanced Concept Technology Demonstration (JL ACTD) will develop and migrate interoperable web-based joint logistics decision support tools (JDSTs) to the Global Combat Support System (GCSS). Focus areas for the JL ACTD correspond to Commander-in-Chief (CINC) and Service requirements to develop JDST capability in the areas of Force Capability Assessment; Logistics Support Concepts and Plan Generation; Distribution, Materiel Management, and Maintenance Analysis; and Visualization. JDSTs will use maturing technologies to provide warfighters and logisticians with the abilities to: assess support force capabilities to perform mission tasks; develop and evaluate logistics operational support plans; and, monitor logistics operations and react to deviations from projected support. These tools will exploit near real-time logistics data sources and will be available to all users via a web-based client server environment that complies with defense information infrastructure (DII) common operating environment (COE) architecture standards and requirements. Key data sources include Joint Total Asset Visibility (JTAV), Joint Personnel Asset Visibility (JPAV), the Global Transportation Network (GTN), the Joint Operational Planning and Execution System (JOPES), and the Global Status of Readiness and Training System (GSORTS). This project will also provide a migration path for evaluating advanced technologies that are being developed by other projects such as the DARPA Advanced Logistics Technology Project (TT-10). This ACTD will support CINC/Joint Task Force (JTF) and Service/Agency logisticians across the entire operational spectrum -- mobilization, deployment, employment, sustainment and redeployment.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Defined operational architecture and network requirements for employment of joint decision support tools for CINCs, Components, and Services that operate within the GCSS environment and exploit near real-time data feeds (JTAV, JPAV, GTN, etc.) into a common operating picture between operations and logistics. (\$ 3.100 Million)
- Designed, developed, and migrated an initial set of web-based joint decision support tools. (\$ 5.590 Million)

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- Finalized plans to demonstrate access to Joint Decision Support Tools (JDST) within the Global Combat Support System (GCSS) environment in a joint warfighting exercise. (\$ 1.100 Million)
- (U) **FY1999 Plans:**
- Develop data access and mediation capability to pull information from mediated data sources and to share data and JDST data products between applications through a common user interface. (\$ 3.000 Million)
  - Expand tool set functionality focusing on Component and Service needs. Derive and graphically display planned force capability estimates for logistics units throughout the deployment sequence at specific nodes over time. (\$ 3.000 Million)
  - Determine, evaluate, display, and compare logistics support concepts to include unit capabilities and select supply class requirements to support one or more operational courses of action. (\$ 2.500 Million)
  - Transition proven tools through the DARPA/Defense Information Systems Agency (DISA) Advanced Information Technology Services (AITS) Joint Program Office (JPO) into GCSS. Demonstrate the capabilities to provide a qualitative force capability assessment and generate a logistics support force structure for CINC/JTF use. (\$ 1.500 Million)

- (U) **FY2000 Plans:**
- Expand development of JDSTs to compare planned logistics unit support capabilities with actual capabilities at specific nodes over time. (\$ 5.000 Million)
  - Expand JDST to integrate in-theater distribution support planning and infrastructure assessment to generate and compare alternative logistics support force concepts to support multiple operational courses of action. (\$ 2.000 Million)
  - Incorporate and enhance planned deviation detection technology and sentinels to compare planned resource requirements with near real-time operational logistics activity for select support items by location, provider, and intended consumer. (\$ 2.000 Million)

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- Exercise and demonstrate advanced JDST capabilities in an expanded joint warfighting exercise. (\$ 1.000 Million)
- (U) **FY2001 Plans:**
  - Develop capability to calculate support unit requirements and sustainment and identify matching sources to meet mission requirements. (\$ 4.000 Million)
  - Develop capability to rapidly assess the impact of operational changes upon the logistics support structure. (\$ 3.500 Million)
  - Develop and demonstrate the capabilities to access commercial and direct vendor data sources, and to interface with Automatic Identification Technology System products. (\$ 1.000 Million)
  - Demonstrate multi-echelon interoperability in a joint warfighting exercise. (\$ 1.500 Million)

(U) **Other Program Funding Summary Cost:** Not Applicable.

(U) **Schedule Profile:** Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE					
RDT&E, Defense-wide BA2 Applied Research					Integrated Command and Control Technology PE 0602708E					September 1998
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
High Definition Systems IC-03	43,994	34,000	32,000	32,000	0	0	0	0	0	N/A

(U) Mission Description:

(U) This program element is budgeted in the Applied Research Budget Activity because it develops the technologies for high definition displays that are important for virtually all DoD applications that involve visual and graphic information. Major components of this program include: projection, head mounted and direct view displays based on multiple technologies; development of equipment and components required to manufacture advanced display technologies; and prototyping of display systems for system evaluation. These efforts will establish a domestic technical capability for the manufacture of components necessary for military systems that capture, process, store, distribute and display high-resolution images.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Continued development of large organic-based display technologies and systems for command and control applications, including laser based projection. (\$ 9.300 Million)
- Continued development of equipment and components to meet display cost and performance goals. This included efforts in printing and microreplication, field emission display materials, organic light emitting materials, phosphor technology development, and support for the domestic display-manufacturing infrastructure. (\$ 23.600 Million)
- Completed high definition optoelectric digital camera development. (\$ 1.900 Million)
- Initiated display glass manufacturing development. (\$ 3.700 Million)
- Continued development of system prototypes, which leveraged previously developed display technologies, particularly for mobile displays and incorporated integrated systems and intelligent interfaces. (\$ 5.494 Million)

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(U) **FY1999 Plans:**

- Complete development of large organic-based display technologies and continue development of displays for command and control applications. (\$ 3.000 Million)
- Continue development of equipment and components to meet display cost and performance goals. This will include efforts in printing and microreplication, field emission display materials, organic light emitting materials, and phosphor technology development. (\$ 12.000 Million)
- Complete first generation integrated display systems and system prototypes for mobile applications. Continue development of large screen command and control system prototypes, to include development of a large area, high resolution, flexible, rugged display (a minimum of 22 inch diagonal, HDTV resolution color display that rolls up like a window shade). (\$ 19.000 Million)

(U) **FY2000 Plans:**

- Develop flexible, rugged displays based on organic electroluminescence and zero-power reflective technology. (\$ 2.000 Million)
- Develop active matrix backplanes on flexible substrates for high performance/low power rugged displays. (\$ 8.000 Million)
- Develop enhanced maturing technologies (color inorganic electroluminescence, field emission, high brightness head mounted displays, etc.) to performance capabilities required for DoD applications. (\$ 6.000 Million)
- Develop roll-to-roll processing for inexpensive, flexible, rugged, displays for DoD applications. (\$ 12.000 Million)
- Demonstrate/insert display technology into DoD systems to evaluate display technology. (\$ 4.000 Million)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Integrated Command and Control Technology PE 0602708E, Project IC-03	September 1998

(U) FY2001 Plans:

- Demonstrate large area, high resolution, and flexible rugged roll-up display. (\$ 12.000 Million)
- Integrate organic light emitting diodes on flexible, active matrix backplanes for increased brightness and reduced power. (\$ 7.000 Million)
- Determine scalability of roll-to-roll processing for large, high-resolution emissive displays. (\$ 3.000 Million)
- Evaluate new display concepts for large, high-resolution displays. (\$ 5.000 Million)
- Demonstrate/insert display technology into DoD systems for display evaluation. (\$ 5.000 Million)

(U) Program Change Summary: (In Millions)

	<u>FY1998</u>	<u>FY 1999</u>	<u>FY2000</u>	<u>FY2001</u>
Previous President's Budget	45.695	34.000	32.000	32.000
Current Budget	43.994	34.000	32.000	32.000

(U) Change Summary Explanation:

FY 1998 Decrease reflects reprogramming to the Small Business Innovative Research program in keeping with statutory directions.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost	
Total Program Element (PE) Cost	213,358	244,408	234,334	269,708	262,206	260,640	275,640	295,640	Continuing	Continuing	
Materials Processing Technology MPT-01	123,481	148,590	136,066	169,827	169,780	164,227	169,227	179,227	Continuing	Continuing	
Microelectronic Device Technologies MPT-02	60,984	84,701	86,722	87,881	77,426	80,413	90,413	100,413	Continuing	Continuing	
Cryogenic Electronics MPT-06	17,608	8,203	11,546	12,000	15,000	16,000	16,000	16,000	Continuing	Continuing	
Military Medical/Trauma Care Technology MPT-07	11,285	2,914	0	0	0	0	0	0	0	N/A	

(U) Mission Description:

(U) This program element is budgeted in the Applied Research Budget Activity because its objective is to develop technology related to those materials, electronics, and biological systems that make possible a wide range of new military capabilities.

(U) The Materials Processing Technology project (MPT-01) concentrates on the development of novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance, and enable new missions for military platforms and systems. Areas of concentration include exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. This emphasis includes lightweight personnel protection, mesoscale machines for miniature devices, and ultra lightweight materials. The project also focuses on smart materials, sensors and actuators, functional materials and devices, advanced magnetic materials for non-volatile, radiation hardened magnetic memories, and electroactive polymers for sensing and actuating. Other areas of concentration include new materials concepts for portable power, protective coating materials to eliminate environmental hazards, infrared artificial dielectrics, development of bio-interface materials and methods, energy harvesting concepts, and frequency agile materials based on ferrite and ferroelectric oxides. This project also includes a biological systems thrust. The unique characteristics of biologically derived functional materials and devices will be exploited through the understanding and control of the structure and

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chemistry of the interface between man-made and biotic materials. In addition, emulation and/or control of biological functionality (i.e., sensing and mobility) will be explored for enhanced DoD sensor, robotic, etc. applications.

(U) The Microelectronics Device Technologies project (MPT-02) develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for optoelectronics and infrared devices. Areas of emphasis include high-performance analog-to-digital converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices, and high power electronics. This project includes a significant effort to develop advanced materials and device technology beyond the classical scaling limits of silicon device technology.

(U) In the Cryogenic Electronics project (MPT-06), thin film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military applications. Thin-film high temperature superconducting components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance while reducing size and power requirements. Highly dependable and inexpensive cryocoolers (including thermoelectric coolers) are being developed for these applications, and expanded efforts will explore techniques to improve the performance of all solid state thermoelectric coolers as well as the overall cryogenic performance in applications ranging from communications to computing.

(U)	<u>Program Change Summary: (In Millions)</u>	<u>FY1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>
	Previous President's Budget	231.353	244.408	234.218	250.208
	Current Budget	213.358	244.408	234.334	269.708

(U) Change Summary Explanation:

FY 1998

Decrease reflects DD1415 transfers of LSTAT program to Army (\$3.9M); Defense Microelectronic Activity to the Defense Logistics Agency (\$9.5M), transition of the Advanced Biomedical Technology program (\$1.4M) and an inflation adjustment (\$3.2M) in accordance with PL 105-56.

FY 2000-01

Increases reflect expansion of efforts in sonoelectronics, VLSI photonics, silicon RF and integrated fluidic cooling developments offset by transfer of Biowarfare related portions of the Biomimetic Systems program to PE 0602383E in accordance with the PDM.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide BA2 Applied Research					Materials and Electronics Technology PE 0602712E, Project MPT-01						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Materials Processing Technology MPT-01	123,481	148,590	136,066	169,827	169,780	164,227	169,227	179,227	Continuing	Continuing	

(U) Mission Description:

- (U) The major goals of this project are to develop novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance and/or enable new missions for military platforms and systems.
- (U) One important area of concentration is the exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. Thrusts in this area include new concepts for lightweight personnel protection, ultra lightweight materials, and multi-functional materials for lowering the weight and increasing the performance of aircraft and spacecraft structures. Approaches are also being developed for reducing the risk in defense acquisitions of using new materials. Smart materials, sensors and actuators for the control of the aerodynamic and hydrodynamic behavior of military systems are being developed and demonstrated to increase performance and lower detectability of aircraft, helicopters and submarines. "Intrinsically smart" materials which provide self-diagnosis and/or self-repair will be developed as well.
- (U) A second major thrust is the development of functional materials and devices. This includes advanced magnetic materials for high sensitivity, magnetic field sensors; non-volatile, radiation hardened magnetic memories with very high density, short access time, infinite cycleability and low power; and electroactive polymers for sensing, actuating, and analog processing. Frequency-agile materials based on ferrite and ferroelectric oxides are being developed for tuned filters, oscillators and antennas. New permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors, generators, flywheels, bearings, and actuators are also being explored.
- (U) The mesoscopic size range ("sugar cube to fist") offers significant advantages in devices for defense. Efforts include mesopumps for battlefield sensors, mesocoolers, and meso air and water purification for the individual soldier. Technology for mask-less, direct-write of mesoscopic integrated conformal electronics will enable the three-dimensional integration of passive components, significantly reducing the size and cost of integrated electronics functions (batteries, antennae, etc.).

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(U) New materials and concepts for increasing the availability of portable power to the soldier are being investigated, as are approaches for deriving power for soldiers and sensors from the environment. Infrared Artificial Dielectrics (IRADs) are a new class of infrared materials having an emissivity that can be fully engineered for different spectral bands. Finally, the unique characteristics of biologically derived functional materials and devices will be exploited through the understanding, control, and emulation of the structure and chemistry of the interface between man-made and biotic materials.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Structural Materials and Devices. (\$ 29.581 Million)
  - Demonstrated low cost titanium and superalloy component fabrication processes.
  - Demonstrated uniformly bonded face sheet attachment on ultra lightweight foamed metal structures.
  - Demonstrated a 5x reduction in prototyping time (print-to-part) for ceramic and metal gas turbine engine components utilizing solid freeform manufacturing.
  - Demonstrated a laser workcell at a beta test site.
  - Established approaches for breakthrough gains in personnel protection performance (e.g., >100 percent improvement from current capabilities for 7.62 mm armor piercing round) through the application of innovative materials, materials processing and phenomenological modeling of multicomponent materials systems.
  - Initiated mesoscale machine demonstrations of interest to the DoD including a miniature air pump and a micro-cooler.
  - Evaluated an Al-Be F-15 rudder spar.
  - Evaluated structurally porous, ultra-lightweight aircraft panels.
  - Completed the fabrication and evaluation of nanostructured, hard carbon coatings with high adhesion, low friction, high hardness and high wear resistance.
- Smart Materials and Actuators. (\$ 24.700 Million)
  - Demonstrated a fabrication process for microintegrated smart materials.
  - Demonstrated full size, smart material active helicopter blade structure and acoustic noise suppression structure on a rotor test stand.
  - Evaluated the actuation potential of magneto-elastic and magneto-shape memory transducer materials.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01	September 1998

- Evaluated high performance electroceramic actuator fabrication processes.
- Demonstrated the applicability of a smart shape adaptive wing to vortex destabilization in hydrodynamic applications.
- Designed, built, tested and evaluated high power laminated actuator stacks for smart defense structures utilizing Computer Aided Manufacturing-Laminated Engineering Materials (CAM-LEM) solid freeform fabrication capability.
- Functional Materials and Devices. (\$ 48.000 Million)
  - Demonstrated a prototype giant magneto-resistive (GMR) magnetic memory array and spin transistor memory cell array using magnetic multilayers.
  - Developed microstructural models for prediction of GMR thin film properties.
  - Designed and built a very high sensitivity magnetometer.
  - Continued polymer development using advanced lithography techniques for infrared artificial dielectrics (IRADs).
  - Demonstrated electroactive optical flow characteristics of polymers.
  - Initiated effort to reduce loss tangent in ferrites and ferroelectric oxides for frequency agile RF components.
  - Demonstrated a switched circulator and phase shifter using thick film ferrites.
  - Selected model systems for establishing the structure, chemistry, and function of biotic/abiotic interfaces and biological systems which provide the capability to design biological and biohybrid devices of interest to the DoD (e.g., sensors, smart membranes, actuators, etc.).
  - Demonstrated high-density electronic interconnects for Seamless High Off-Chip Connectivity (SHOCC) interposer.
- Energy and Environmental Sciences. (\$ 21.200 Million)
  - Developed balance-of-plant and packaging for a direct oxidation fuel cell replacement for military standard batteries.
  - Demonstrated that full scale, intelligent processing of copper-indium diselenide (CIS) solar cells yields both performance and cost (<\$1/watt) suitable for use of flexible photovoltaics in military operations.
  - Developed energy harvesting and storage concepts for unattended devices.
  - Demonstrated the utility of advanced erosion/corrosion resistant thin film coatings at a military site.
  - Demonstrated intelligent processing of thermal barrier coatings yielding reliable coatings, which increase turbine engine inlet temperatures by up to 200 degrees F, with a commensurate increase of 10-15% in thrust.
  - Demonstrated effective silicon-based fouling release coatings for military vessels that offer the potential for maintenance free, cost-effective, non-toxic alternatives to existing anti-fouling paints.

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(U) FY1999 Plans:

- Structural Materials and Devices. (\$ 33.490 Million)
  - Fabricate and test materials and materials systems concepts designed to significantly improve personnel protection performance (e.g., >100 percent improvement from current capabilities for 7.62 mm armor piercing round), dramatically increasing protection for the individual soldier.
  - Demonstrate solid freeform fabrication of titanium forging blanks.
  - Demonstrate spray forming of superalloy forging billets.
  - Demonstrate the use of solid freeform fabrication to upgrade distressed turbine vanes in man-rated gas turbine engines with ceramic composite components of high reliability.
  - Demonstrate initial feasibility and performance of prototype mesoscale machines (miniature air blower, microcooler, meso pump, etc.).
- Smart Materials and Actuators. (\$ 27.100 Million)
  - Demonstrate vortex wake reduction for submarines using smart materials.
  - Demonstrate submarine acoustic noise reduction using smart material tiles.
  - Demonstrate a shape adaptive fighter inlet.
  - Establish growth conditions for large piezoelectric single crystals from flux using both open and closed crucible techniques.
  - Evaluate the impact of piezoelectric single crystals on Navy low-frequency surveillance sonar, mid-frequency navigation/tactical sonar, and high-frequency weapons guidance sonar.
- Functional Materials and Devices. (\$ 62.800 Million)
  - Demonstrate high speed, radiation hard, medium density, and non-volatile magnetic memory utilizing magnetic multilayers; develop methods for controlling the microstructure of these giant magneto-resistive (GMR) films during growth.
  - Demonstrate very high sensitivity magnetometer and gradiometer for localization of magnetic anomalies.
  - Demonstrate a permanent magnet material with a 50 percent higher strength (energy product).
  - Expand the use of solid freeform fabrication to demonstrate a new process for the fabrication of silicon carbide devices using rapid tool-less vapor deposition processes.
  - Complete polymer development for infrared artificial dielectrics (IRADs).

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- Demonstrate the actuation capability of polymeric muscles.
  - Demonstrate a loss tangent less than 0.002 in hybrid ferrite/ferroelectric frequency agile filters.
  - Demonstrate a voltage-controlled oscillator (VCO) with an octave tuning range and low loss. Demonstrate scale-up capability for single crystal growth utilizing x-ray interference patterns to template crystal growth.
  - Demonstrate enhanced biological responses (molecular, cellular and organismal) at modified material interfaces. Identify approaches for the neurological control and behavior of simple biological systems through biomaterial development.
  - Demonstrate actuator materials and bioinspired control strategies for biomimetic locomotion systems; develop biomimetic systems that incorporate extremophile strategies for enhanced stability and performance in the environmental extremes required by the DoD.
  - Select available functional elements for preliminary experiments and establish system specifications for tropomorphic systems, i.e., systems which self-adaptively shed, heal morph and grow to meet operational requirements.
- Energy and Environmental Sciences. (\$ 25.200 Million)
    - Demonstrate a low temperature, packaged direct oxidation fuel cell for soldier applications.
    - Demonstrate alternative energy sources (including thermal energy conversion) for soldier microclimate cooling and for portable battery chargers.
    - Demonstrate energy harvesting concepts from ambient sources for unattended sensor applications.
    - Investigate fate and transport of chemicals in soil as well as chemotaxis schemes for localization of sources.
    - Demonstrate approaches to augment portable power sources by recovering energy from human activity.
    - Complete demonstration and insertion of advanced erosion/corrosion resistant and anti-fouling thin film coatings in military systems.

**FY2000 Plans:**

(U)

- Structural Materials and Devices. (\$ 22.066 Million)
  - Integrate material concepts and materials systems into ultra-lightweight armor providing 100 percent improvement in personnel protection for the soldier.
  - Develop analytical, experimental, and simulation technologies for predicting the cost, performance, and life of advanced materials, decreasing the risk of and accelerating the time for insertion of new materials in defense acquisitions.

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- Mesoscopic Structures and Devices. (\$ 13.800 Million)
  - Demonstrate the operation of a mesoscopic pump array with flow rates over 5 liters/min. in one cubic inch.
  - Build and test an individual integrated mesoscopic cooler.
  - Demonstrate a mesoscopic vacuum pump integrated with a mass spectrometer on a chip.
  - Demonstrate the ability to directly write passive electronic materials and components at the mesoscale.
  - Demonstrate prototype active materials (ferrites and ferroelectrics) via direct fabrication at the mesoscale.
- Smart Materials and Actuators. (\$ 25.500 Million)
  - Demonstrate 20-dB vibration reduction (1/4 scale demo) using active hybrid mounts on equipment racks for ships.
  - Demonstrate improvements in aerodynamic performance through wind tunnel testing of wings with adaptive leading and trailing edge control surfaces.
  - Develop a "smart skin" for the reduction of self-noise and radiated noise in torpedoes.
  - Demonstrate polymeric actuators that emulate the mechanical response and performance of human muscles.
  - Demonstrate the performance of single crystal piezoelectrics in broadband ultrasonic imaging transducers.
  - Demonstrate techniques to grow large (>3cm) single crystals of relaxor piezoelectrics.
- Functional Materials and Devices. (\$ 58.600 Million)
  - Demonstrate very fast (<20 nsec access time) at high density, radiation hard magnetic memory circuits utilizing both giant magnetoresistance (GMR) multilayers and spin dependent tunneling devices; fully understand the micromagnetics of magnetic domain rotation in these devices.
  - Demonstrate very small, low power, high sensitivity magnetic gradiometers for the localization and identification of small ferrous objects.
  - Demonstrate permanent magnet materials with 75 percent higher magnetic strength (energy product) and the ability to preserve magnetic properties to temperatures over 250 C.
  - Demonstrate a loss tangent less than 0.001 in hybrid ferroelectric/ferrite devices.
  - Demonstrate a broadband 360-degree phase shifter with very low loss for antenna feed applications.
  - Demonstrate green light-emitting diodes (LED) fabricated from electroactive polymers, with a half-life >5,000 hours; demonstrate blue and red LEDs with >1,000 hours half-life.
  - Select appropriate polymeric materials with electronic characteristics for field-effect transistor (FET) development.

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- Demonstrate growth of AlGaSb-InAs thin films on GaAs substrates using the lateral epitaxial overgrowth technique.
- Demonstrate lattice mismatched epitaxial growth of dislocation free compound semiconductors using strain-absorbing layers.
- Determine sensorimotor and navigational control schemes for biological systems through microelectronic interfaces.
- Evaluate chemical, visual, and acoustic cues used by biological systems for controlled locomotion, behavior, and distribution.
- Evaluate computational neuromechanics and biomechanics of locomotion.
- Advanced Energy Technologies. (\$ 16.100 Million)
  - Demonstrate and field test compact portable power systems in soldier applications.
  - Develop high efficiency direct thermal to electric energy conversion.
  - Demonstrate in the laboratory a compact >500 W battery charger operating on logistics fuel.
  - Demonstrate in the laboratory power generation from ambient sources capable of operating unattended ground sensors.

## (U) FY2001 Plans:

- Structural Materials and Devices. (\$ 27.827 Million)
  - Demonstrate ultra-lightweight armor with 100 percent improvement over current materials and begin transition of manufacturing/design capabilities to the Army.
  - Demonstrate the use of multifunctional materials to provide an order of magnitude improvement in the capabilities of specific defense systems.
  - Continue the optimization of analytical, experimental, and simulation technologies for predicting the properties of advanced materials.
  - Select specific material(s) of high value to a DoD system for demonstration of accelerated insertion concepts.
- Mesoscopic Structures and Devices. (\$ 17.900 Million)
  - Demonstrate mesoscopic compressor operation that can work against 4 times atmosphere pressure.
  - Demonstrate a mesh of fully functional integrated mesoscopic coolers that exhibit a coefficient of performance >4 and have 1/3 the weight of the smallest normal-scale coolers.
  - Demonstrate that direct-write mesoscale active and passive components have functionality equivalent to discrete surface mount components.
  - Demonstrate the rapid integration of direct-write passive components with integrated circuits.

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- Demonstrate the ability to direct-write mesoscale passive components, batteries, and capacitors on complex geometries.
- Fabricate x10 gain patch antenna that has the same footprint as a commercial antenna on a conformal substrate.
- Smart Materials and Actuators (\$34.300 Million)
  - Complete wind tunnel test verification of an active aircraft engine inlet enabling a 20 percent increase in aircraft mission radius compared to a conventional fixed geometry inlet design.
  - Complete water tunnel test of a subscale submarine propulsor with active control to reduce acoustic radiation levels.
  - Complete flight test for rotorcraft with blades containing integral actuators and flaps for control of noise and vibration.
  - Develop techniques that use the intrinsic response of a material to its operating environment to provide diagnosis of the performance life of the material.
  - Develop "intrinsically smart" materials that monitor their own state of "health" and repair themselves as required.
  - Demonstrate methods to fabricate multilayer actuators made from single crystals of relaxor piezoelectrics.
  - Demonstrate high strain performance (>0.5 percent) of single crystal piezoelectrics in electromechanical actuators.
  - Demonstrate the performance of single crystal piezoelectrics in an advanced Navy sonar transducer.
- Functional Materials and Devices. (\$59.700 Million)
  - Demonstrate a prototype radiation hard, very high density (>64 Mbit), high speed (<10 nsec access time) magnetic memory circuit based on giant magneto-resistance (GMR) or spin-dependent tunneling utilizing very low power and low voltage (<2.5 Volts).
  - Design a prototype slotless integral motor/pump with advanced magnetic materials for improved efficiency and performance.
  - Demonstrate a steerable ferroelectric lens for phased array radar.
  - Demonstrate a conformal, frequency agile antenna that is 100x smaller than conventional technology.
  - Demonstrate electronic mobility of  $>10^{-4}$  cm<sup>2</sup>/Vs in electroactive polymeric materials.
  - Demonstrate a large area fabrication process for polymeric light-emitting diodes (LEDs).
  - Demonstrate the use of electroactive polymers as thin film spatial filters for quasi-real-time multispectral image analysis for enhancing target detectability.
  - Fabricate a preamplifier for a millimeter wave radar front end with a 4-dB improvement in sensitivity using lateral epitaxial overgrowth fabrication capabilities.
  - Demonstrate the use of twist bonded substrates for integration of an infrared focal plane with integrated read-out electronics.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01	September 1998

- Bioinspired Materials and Devices. (\$ 8.800 Million)
  - Identify candidates for advanced sensor systems that incorporate biologically inspired concepts including self-calibration, self-healing, variable temperature operation, functionally responsiveness, and mobility.
  - Construct prototype microelectronic interfaces for control of biological systems.
  - Demonstrate millimeter to centimeter scale actuators that emulate the locomotion of biological systems.
- Advanced Energy Technologies. (\$ 21.300 Million)
  - Demonstrate a compact turbo-generator with improved efficiency for portable power and battery charger applications utilizing ceramic components and operating on logistics fuel.
  - Demonstrate energy harvesting from ambient sources for unattended sensor applications.
  - Field test integrated energy harvesting systems in soldier applications.
  - Demonstrate in the laboratory high efficiency direct thermal to electric energy conversion operating on a hydrocarbon fuel.
  - Develop and demonstrate advanced ultra-high energy density power source concepts.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide BA2 Applied Research					Materials and Electronics Technology PE 0602712E, Project MPT-02						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Microelectronic Device Technologies MPT-02	60,984	84,701	86,722	87,881	77,426	80,413	90,413	100,413	Continuing	Continuing	

(U) Mission Description:

(U) This project develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for Optoelectronics, and infrared devices. Areas of emphasis include high performance analog-to-digital (A/D) converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices, and high power electronics. This microelectronics development project develops and demonstrates advanced microelectronics technology for DoD critical needs including digital radar receivers and acoustic-electronic components. Technologies developed in this project are performance driven and exceed commercial capabilities. This project includes a significant effort to develop advanced material and device technology beyond the classical scaling limits of silicon device technology.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Advanced Microelectronics - Chose candidate interconnect/stacking strategies. (\$ 2.400 Million)
- Developed SiC materials for High Power Electronic Power Switching Devices in the 250°- 350°C range demonstrating 1 1/2 inch diameter wafers with less than one micropipe defects per centimeter squared. (\$ 1.700 Million)
- Evaluated thermal management strategies for megawatt-class power switch; evaluated approaches for controlling high-power switch with solid-state electronics (monolithic vs. hybrid); demonstrated 1000-V-class SiC switch. (\$ 4.600 Million)
- Explored photonic approaches in the throughput of analog-to-digital (A/D) converters. (\$ 3.000 Million)
- Digital Receiver Processor - Continued efforts to develop advanced digital-based processor components based on high-speed semiconductor technologies, such as heterojunction bipolar transistors. (\$ 12.000 Million)

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- Sonoelectronics - Initiated development of highly effective sonoelectronic actuators and transducers that can be integrated directly with silicon Very Large Scale Integrated (VLSI) circuits. (\$ 7.300 Million)
- VLSI Photonics - Demonstrated feasibility of integration of small arrays (4x4) vertical cavity surface emitting lasers with detectors, and identified degradation mechanism for polymer/small molecule lasers and demonstrated photopumped lasing. (\$ 11.100 Million)
- Low Power Electronics - Developed circuits and circuits level design tools to reduce power dissipation for variety of circuits and assist in circuits level tradeoffs. (\$ 0.900 Million)
- 3-D Microelectronics - Developed and demonstrated key technologies behind a packaging concept that used a stacked MCM approach to reduce interconnect length and increase physical connectivity between layers of electronics. (\$ 4.600 Million)
- Mixed-Mode Electronics - Initiated mixed-mode electronics multitechnology insertion (MIME). (\$ 7.000 Million)
- Nanofabrication - Investigated areas of nanofabrication of electronic devices and extreme ultraviolet (EUV) lithography to be used in the next decade for the fabrication of semiconductor devices, such as nanoelectronics and micromechanical structures. (\$ 5.600 Million)
- RF Photonics - Completed research in Radio Frequency Photonics. (\$ 0.784 Million)

(U) **FY1999 Plans:**

- Advanced Microelectronics - Characterize candidate 25-nm transistors (150nm)<sup>2</sup> total area and establish process sequence for chip for proof-of-principle demonstration. (\$ 8.133 Million)
- Digital Radar Receiver Processor - Develop advanced digital processor components. (\$ 11.000 Million)
- Continue development of SiC materials for High Power Electronic Switching Devices increasing water diameter and lowering defect density. (\$ 2.000 Million)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02	September 1998

- Demonstrate high current density ( $>100 \text{ A/cm}^2$ ) 1000-V-class SiC high power switch; demonstrate high-temperature ( $>250 \text{ C}$ ) operation of a 1000-V-class switch. (\$ 7.000 Million)
- VLSI Photonics - Demonstrate integrated 8x8 VLSI photonics chip (laser, detector and electronics) and optoelectronic modeling tools compatible with electronic CAD tools and demonstrate the feasibility of using molecular self-assembly techniques to position optoelectronic devices with high precision on silicon circuits. (\$ 20.000 Million)
- Sonoelectronics - Carry out full sonoelectronic integration, combining surface micromachined transducer arrays, low-noise Complementary Metal Oxide Semiconductor (CMOS) electronic readout, acoustic lens and packaging technology, and low-power display technology to fabricate high resolution underwater imager. Begin designing transducers, arrays, and integration approach for air-coupled operation. (\$ 16.000 Million)
- HERETIC - Demonstrate heterostructure integrated thermoelectric (TE) or thermionic devices having the same heat-removal capacity as the best commercial off-the-shelf (COTS) TE coolers; fabricate micro-jets, micro-nozzles or micro-thermionic emitters capable of monolithic integration with Si circuits. (\$ 5.000 Million)
- Explore new concepts for integration of multiple materials on silicon chips. (\$ 2.000 Million)
- Explore concepts in new device technology for 3-D imaging of targets and lightweight electronically steered lasers. (\$ 4.568 Million)
- Initiate silicon Reconfigurable Aperture (RECAP) program. Demonstrate microswitches with very low insertion loss, high isolation, and low actuation voltage. Develop fabrication processes for embedded RF microcomponents on large area substrates. (\$ 9.000 Million)

(U) **FY2000 Plans:**

- (RECAP) - Demonstrate capability to produce large arrays of microswitches. Begin development of integration technologies for switch layers with signal distribution layers. (\$ 18.000 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02	September 1998

- Digital Receiver Technology Program - Demonstrate a very high performance analog-to-digital (A/D) converter with 14 effective bits, 60 MHz instantaneous bandwidth, and >86 dB spurious free dynamic range (SFDR) in FY00 with potential for multiple military applications. (\$ 2.000 Million)
  - High-powered Solid State Electronics - Demonstrate high-current density ( $>100 \text{ A/cm}^2$ ) 2500-V class switch from SiC; demonstrate 2500-V rectifier diode from GaN. (\$ 3.000 Million)
  - Sonoelectronics - Complete sonoelectronic camera prototype fabrication, and carry out laboratory characterization and test-tank demonstration. Carry out sonoelectronic integration for air-couple arrays including acoustic matching and electronic read-out technologies. (\$18.500 Million)
  - HERETIC - Complete integration of HIT device arrays with bias and control circuitry on GaAs substrates; complete integration of micro-jet, micro-nozzle or micro-thermionic arrays with bias and control circuitry over Si substrates. (\$ 10.200 Million)
  - Advanced Microelectronics (AME) - Demonstrate circuit and modeling of a full-scale system (e.g. image processing system) featuring terascaled-compatible devices and associate technology far beyond the existing industry roadmap. (\$ 15.000 Million)
  - VLSI Photonics - Develop VLSI heterogeneous integration technology and integrate micro-opto-mechanical components with VLSI chips; develop system-level CAD tools. (\$ 20.022 Million)
- (U) **FY2001 Plans:**
- (RECAP) - Develop electronic ground plane technology that provides minimal phase shift and high reflectivity. Demonstrate integration processes for all layers and begin development of combined control function for electronic RF aperture. (\$ 23.000 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02	September 1998

- Sonoelectronics - Integrate advanced transducer and acoustic-lens technologies into prototype camera. Demonstrate lab-proven imager in very-shallow-water (VSW) field setting. Carry out laboratory demonstration of an air-coupled array as an electronically steered microphone array. (\$ 22.900 Million)
- HERETIC - Demonstrate HIT devices on GaAs having twice the specific heat-removal capacity as the best COTS TE coolers; demonstrate micro-jets, micro-nozzles, or micro-thermionic emitters on Si having 5x the heat-removal capacity as the best convective air or liquid cooling systems. (\$ 19.000 Million)
- VLSI Photonics - Demonstrate SAR processor using VLSI Photonics technologies; showcase reconfigurable cross-connect switching. Demonstrate rapid parallel access to memory using optical interconnection. (\$ 22.981 Million)

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defensewide BA2 Applied Research					Materials and Electronics Technology PE 0602712E, Project MPT-06						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Cryogenic Electronics MPT-06	17,608	8,203	11,546	12,000	15,000	16,000	16,000	16,000	Continuing	Continuing	

(U) Mission Description:

(U) Thin film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military systems. Films may be deposited and patterned to form electromagnetic components in ways that are similar to, and compatible with, the processes of conventional semiconductor manufacturing. Such electromagnetic components, as well as complementary metal oxide semiconductors (CMOS), work best at lower temperatures, so that cryogenic packaging generally will be required for optimum performance. Thin-film high temperature superconducting (HTS) components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance by more than an order of magnitude while reducing size and power requirements. Particular demonstrations include upgraded ship-defense radar (SPQ-9B) with 100X greater detectability of missiles in littoral clutter and communications receivers with greater immunity to interference. Highly dependable and inexpensive cryocoolers are also being developed for these applications. These latter development efforts include the exploration of techniques to improve the performance of solid-state thermoelectric materials and devices in applications ranging from communications to power generation.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Cryogenics Technologies. (\$ 13.669 Million)
  - Demonstrated a fully functional Cryo-Radar, with 103 dB dynamic range, 15 dB greater than present performance, showing capability to detect targets over that range and an ability to address the defense of surface ships to attacking missiles.
  - Demonstrated, in flight test, a multi-band receiver for the Joint Airborne SIGINT (Signals Intelligence) Avionics Family (JASAF) configuration.
  - Demonstrated the ability to detect low-level unintended radiation at ranges exceeding 50 km.
  - Demonstrated an improved analog to digital (A/D) converter employing cryogenic components.
  - Demonstrated a low-cost (less than \$2,500), highly reliable (greater than 30,000 hr) Sterling cycle cryocooler that delivers 5 watts at 80K with less than 200 watts of total power.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defensewide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-06	September 1998

- Thermoelectric Materials and Devices. (\$ 3.939 Million)
  - Demonstrated a thermoelectric cooler that provides a reduction in temperature greater than 50°C in a single stage.
- (U) **FY1999 Plans:**
  - Cryogenics Technologies. (\$ 3.203 Million)
    - Insert cryogenic packages in communication transceivers that mitigate electromagnetic interference effects.
  - Thermoelectric Materials and Devices. (\$ 5.000 Million)
    - Demonstrate thermoelectric coolers that can achieve 100°C cooling in less than three stages as compared to the current seven stages.
    - Demonstrate potential benefit of efficient power generation from thermoelectric devices operating at high temperature (>500°C).
- (U) **FY2000 Plans:**
  - Cryogenics Technologies. (\$ 6.446 Million)
    - Develop devices and components, based upon superconducting and other electromagnetic materials, that in a cryogenic environment would provide a 5-10X-range improvement over conventional means for detection of low-level signals.
    - Complete adaptation of cryocoolers in microelectronics packages for communications transceivers.
  - Thermoelectric Materials and Devices. (\$ 5.100 Million)
    - Demonstrate thermoelectric coolers that can achieve 100°C cooling in two stages or less.
    - Demonstrate >100% more power generation (per unit size) utilizing thermoelectric converters than those in use prior to 1998.

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(U)

**FY2001 Plans:**

- Cryogenics Technologies. (\$ 8.500 Million)
  - Fabricate a cryogenic module, operating as a front-end pre-selector, to enhance the sensitivity of a receiver to detect low-level emitters in the presence of multiple interferors.
  - Design a complete cryogenic receiver module, incorporating tunable high temperature superconducting (HTS) antenna/pre-selector and digital microelectronics (with HTS embedded passives), displaying unsurpassed sensitivity and interference rejection.
- Thermoelectric Materials and Devices. (\$ 3.500 Million)
  - Demonstrate an all solid state cooler (or thermal converter) that is competitive with conventional phase change systems.

(U)

**Other Program Funding Summary Cost:** Not Applicable.

(U)

**Schedule Profile:** Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-07						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Military Medical/Trauma Care Technology MPT-07	11,285	2,914	0	0	0	0	0	0	0	N/A	

(U) Mission Description:

(U) The DARPA Combat Casualty Care program has two major segments: (1) Advanced Biomedical Technology (ABT) and (2) Ultrasonic Diagnostic Imaging. The ABT segment exploits DARPA's unique leadership role in the electronics and information sciences to project advanced medical care into the far-forward battlefield area to effect early, successful clinical intervention. This thrust finishes in FY98. DARPA has worked with the US Army Medical and Material Command to develop lightweight personnel status monitors (PSMs) permitting casualty identification and localization. Additional sensor capabilities were developed through a "smart tee-shirt," called the sensate liner, which is a fabric woven with fiber-optic, piezoelectric, and other fibers with additional microprocessors, to provide an entire suite of sensors for vital signs and physiologic monitoring.

(U) The Ultrasonic Diagnostic Imaging segment is developing high-fidelity diagnostic imaging primarily for the far-forward battlefield environment. The emphasis of this effort is on enhancing and miniaturizing biomedical applications of ultrasound. For example, in conventional ultrasound imaging, the medium (i.e., human tissue) is inhomogeneous and scatters the signal, which blurs the image. The processes for developing high-resolution imaging will build upon the emerging technology of adaptive acoustics, the displays of which are intuitive and easily interpreted by the combat medic and physician.

(U) This work does not duplicate any efforts of the Military Services or the National Institutes of Health. A Memorandum of Agreement exists between the Army Medical Department and DARPA.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-07	September 1998

- (U) Program Accomplishments and Plans:
- (U) FY1998 Accomplishments:
- Advanced Biomedical Technology. (\$ 6.068 Million)
    - Completed sensor development for Personnel Status Monitor (PSM) system and transitioned to the Army.
    - Completed microminiaturized oxygen saturation sensor.
    - Developed and integrated the sensate liner's suite of microsensors.
  - 3-D Ultrasound. (\$ 5.217 Million)
    - Continued development, test and evaluation of 2-D array ultrasound transducer for portable applications.
    - Continued digital signal processing (DSP) for high-resolution, high signal-to-noise (S/N) ultrasound image.
- (U) FY1999 Plans:
- 3-D Ultrasound Technologies. (\$ 2.914 Million)
    - Complete ultrasound enhancements for scattering, deaberration, and beam forming; demonstrate resulting system; and transition to the Services.
- (U) FY2000 Plans: Not Applicable.
- (U) FY2001 Plans: Not Applicable.
- (U) Other Program Funding Summary Cost: Not Applicable.
- (U) Schedule Profile: Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide					Advanced Aerospace Systems						
BA3 Advanced Technology Development					PE 0603285E						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Advanced Aerospace Systems ASP-01	0	0	20,000	19,000	23,000	5,000	5,986	9,986	Continuing	Continuing	

(U) Mission Description:

(U) The Advanced Aerospace Systems program element is budgeted in the Advanced Technology Development Budget Activity because it will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted.

(U) The supersonic Low Cost Cruise Missile Interceptor (SLCCM) program will demonstrate an inexpensive supersonic air platform with a low cost uncooled infrared (IR) sensor to provide cruise missile defense by exploiting large rear aspect IR signatures and overtaking incoming missiles from the rear. As a further cost reduction, the program will leverage off the existing miniature air-launched decoy (MALD) program's technology and off board surveillance and tracking sensors to provide tail-on missile end game opportunities (MALD is funded in FY 1999 from Project TT-06, PE 0602702E).

(U) The Navy and the Marine Corps have a need for affordable, survivable, vertical take-off and landing (VTOL) unmanned air vehicles (UAV) to support dispersed units in littoral and urban areas. The Defense Advanced Research Projects Agency (DARPA), in partnership with the Office of Naval Research (ONR) and industry, have formulated a program to explore two innovative vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first, an advanced Canard Rotor/Wing (CRW) aircraft, offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. Detailed design, fabrication and flight test of this scaled vehicle concept will be conducted to validate the command and control, stability and control system and aerodynamic performance required for vertical take-off, landing and hover via a rotating center wing which is stopped and locked in place for efficient high speed cruise. The second concept (A160), will exploit a hingeless, rigid, rotor concept to produce a VTOL UAV with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>2000 nm) and endurance (>24-48 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability,

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maintainability and performance. The A160 and CRW programs were initiated in FY 1998 under PE 0602702E, TT-07, Aeronautics Technology, but are funded in ASP-01 beginning in FY 2000 in recognition that their technological maturation dictates Budget Activity 3 placement.

(U) The Advanced Space Transportation and Robotic Orbiter (ASTRO) program will develop one or more approaches to "affordability" place small (<100kg) payloads in space for the purpose of servicing, upgrading, or reconfiguring satellites. An important element of ASTRO is the projected economic impact of such capability on current space missions and its potential for enabling new space missions. Phase I program elements will address novel launch techniques (gas guns, small expendable vehicles, small recoverable vehicles); small payload concepts and designs (expandable replacement, subsystem replacement/upgrade, reconfiguration); robotic space operations; and modular, serviceable satellite designs. Given an economically viable and technically achievable approach from Phase I, Phase II will develop needed technologies and demonstrate the concept on orbit.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments: Not Applicable.

(U) FY1999 Plans: Not Applicable

(U) FY2000 Plans:

- Continue fabrication and conduct hardware in the loop and ground testing of Canard Rotor/Wing (CRW) and A160 concepts. (\$ 10.000 Million)
- Supersonic Low Cost Cruise Missile Interceptor (SLCCMI): Conduct engine and low cost miniature sensor testing, fabricate, assemble and conduct ground and early risk reduction testing of air vehicle. Initiate detail test planning for flight demonstration. (\$ 7.000 Million)
- Advanced Space Transportation and Robotic Orbiter (ASTRO): Conduct assessment and affordability analysis of potential launch concepts; preliminary design of preferred low cost launch systems, including the robotic transfer vehicle; develop test plan for launch demonstration; conduct preliminary design for satellite concepts that enable robotic on-orbit servicing and upgrade; conduct proof-of-concept tests for robotic servicing concepts. (\$ 3.000 Million)

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	September 1998	
BA3 Advanced Technology Development	Advanced Aerospace Systems PE 0603285E, Project ASP-01		

(U) FY2001 Plans:

- Supersonic Low Cost Cruise Missile Interceptor (SLCCMI): Perform supersonic engine flight verification and seeker/warhead verification. Conduct Flight Demonstration of supersonic vehicle. (\$ 7.000 Million)
- Complete fabrication and conduct flight-testing of CRW and A160 concepts. (\$ 5.000 Million)
- Perform critical design review for preferred launch concept, robotic transfer vehicle, and spacecraft; conduct critical component launch demonstration. (\$ 7.000 Million)

(U)	<u>Program Change Summary: (In Millions)</u>	<u>FY1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>
	Previous President's Budget	0.000	0.000	0.000	0.000
	Current Budget	0.000	0.000	20.000	19.000

(U) Change Summary Explanation:

FY 2000-01 Increases reflect transfer of the CRW and A160 efforts from PE 0602702E and initiation of the SLCCMI and ASTRO programs.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Oct 99	Canard Rotor/Wing (CRW) Critical Design Review.
Nov 99	Conduct Supersonic Low Cost Cruise Missile Interceptor (SLCCMI) Requirements Definition.
Feb 00	Canard Rotor/Wing Detailed Design Review.
Jan 00	Flight test A160 air vehicle.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, Project ASP-01	September 1998

Jan 00	Select preferred Advanced Space Transportation and Robotic Orbiter (ASTRO) system concept.
Jan 00	Conduct Preliminary Design Review (PDR) for ASTRO System.
Jun 00	Complete CRW ground testing.
Aug 00	Complete A160 flight control system testbed flights.
Aug 00	Complete ASTRO Flight Test Demonstration Plan.
Sep 00	Conduct ASTRO Proof-of-Concept demonstration.
Oct 00	Perform SLCCMI Preliminary Design Review after conducting performance trades.
Oct 00	Canard Rotor/Wing Detailed Design Review.
Oct 00	CRW Rollout of Air Vehicle No. 1.
Dec 00	Conduct Critical Design Review (CDR) for ASTRO System.
Jan 01	Flight Test CRW Air Vehicle.
Feb 01	Complete A160 final flight test of air vehicles 1, 2, and 3.
Mar 01	Demonstrate SLCCMI low cost seeker requirements.
Jun 01	CRW flight tests completed.
Jun 01	SLCCMI demonstrates higher thrust output of TJ-50 derivative.
Sep 01	Complete ASTRO Critical Component Demonstration.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost	
Total Program Element (PE) Cost	272,176	244,737	247,014	245,348	235,109	244,417	255,979	254,979	Continuing	Continuing	
*Uncooled Integrated Sensors MT-03	8,289	11,000	3,000	0	0	0	0	0	0	N/A	
Electronic Module Technology MT-04	66,732	68,892	61,142	47,395	53,999	81,363	84,925	86,925	Continuing	Continuing	
Tactical Information Systems MT-05	28,328	36,596	19,640	22,748	21,100	0	0	0	0	N/A	
Microwave and Analog Front End Technology MT-06	17,543	4,000	0	0	0	0	0	0	0	N/A	
Centers of Excellence MT-07	4,844	4,000	0	0	0	0	0	0	0	N/A	
Manufacturing Technology Applications MT-08	26,175	22,200	20,253	0	0	0	0	0	0	N/A	
Advanced Lithography MT-10	49,710	26,500	28,000	24,000	27,500	24,754	24,754	24,754	Continuing	Continuing	
Microelectromechanical Systems (MEMS) MT-12	70,555	71,549	78,979	80,000	79,000	88,300	96,300	93,300	Continuing	Continuing	
Mixed Technology Integration MT-15	0	0	36,000	71,205	53,510	50,000	50,000	50,000	Continuing	Continuing	

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development		R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E	September 1998

(U) Mission Description:

- (U) The Advanced Electronics Technology program element is budgeted in the Advanced Technology Development Budget Activity because it seeks to design and demonstrate state-of-the-art manufacturing and process technologies for the production of various electronics and microelectronic devices, sensor systems, actuators, and gear drives that have both commercial and military applications. Introduction of advanced product design capability and flexible, scalable manufacturing techniques will enable the commercial sector to rapidly and cost-effectively satisfy military requirements and enhance the US industrial base.
- (U) The Uncooled Integrated Sensors project addresses a long standing Defense requirement for uncooled, solid state advanced infrared sensor arrays for major weapons systems that do not require costly cryogenic cooling packages.
- (U) The Electronic Module Technology project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog, and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards and emerging technologies such as high density Multichip Modules (MCMs).
- (U) The Tactical Information Systems project contains three major programs: Head Mounted Displays (HMD), Smart Modules, and Warfighter Visualization. The Head Mounted Display program is developing world-class miniature displays and integrating these displays into head and helmet mounted configurations for use by pilots, combat vehicle crews and individual warriors, as well as for virtual environments and simulation. Smart Modules is a program to design and develop prototype modules, using core technologies that sense, think, and communicate, and integrate them into selected personal information products. Warfighter Visualization is a program to demonstrate the feasibility of combining real-time visual images of the environment with geospatially registered computer generated information for use by individual mounted and dismounted warfighters.
- (U) The goal of the Manufacturing Technology Applications project is to reduce the cost and acquisition lead time of future military systems by integrating manufacturing process considerations during the product design phase, and by demonstrating high efficiency multi-product prototype factories. This project will also enable manufacturers to economically produce military variants of their commercial products in limited quantities through the introduction of flexible process technologies. It is scheduled to complete after FY 2000.

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APPROPRIATION/BUDGET ACTIVITY		R-1 ITEM NOMENCLATURE	
RDT&E, Defense-wide		Advanced Electronics Technologies	
BA3 Advanced Technology Development		PE 0603739E	

(U) Advanced Lithography technology has enabled the dramatic growth of integrated circuit capability. Advances have led directly to improvements in electronic and computing systems performance in terms of speed, power, weight and reliability.

(U) The Microelectromechanical Systems (MEMS) project is a broad and cross-disciplinary initiative to develop an enabling technology that merges computation with sensing and actuation to realize new systems for both perceiving and controlling weapons systems, processes and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiple components, and integrated microelectronics to the design and construction of integrated electromechanical systems. The microfluidic molecular systems program will address issues centered around the development of automated microsystems that integrate biochemical fluid handling capability along with electronics, opto-electronics and chip-based reaction and detection modules to perform tailored analysis sequences for monitoring of environmental conditions, health hazards, and physiological states.

(U) The goal of the newly established Mixed Technology Integration project is to revolutionize the integration of mixed technologies at the micrometer/nanometer scale. This will produce low-cost, lightweight, low-power 3-D microsystems that improve battlefield awareness and the operational performance of military platforms. This project will leverage industrial manufacturing infrastructure to produce mixed-technology microsystems that will revolutionize the way warfighters see, hear, taste, smell, touch and control environments.

(U) Two on-going DARPA projects complete in FY 1999: MAFET (MT-06) and Centers of Excellence (MT-07). The Microwave and Analog Front End Technology (MAFET) project has been directed at significantly reducing non-recurring costs for military microwave/millimeter wave sensor systems through improved computer aided design capabilities. The Centers of Excellence project has financed demonstration, training and deployment of advanced manufacturing technologies.

(U)	<b>Program Change Summary: (In Millions)</b>	<b>FY1998</b>	<b>FY 1999</b>	<b>FY 2000</b>	<b>FY 2001</b>
	Previous President's Budget	281.909	244.737	259.014	212.385
	Current Budget	272.176	244.737	247.014	245.348

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development		R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E	September 1998

(U)

Change Summary Explanation:

FY 1998

Decrease reflects the deferral of boot-mounted navigation device initiative in Tactical Information Systems, the accelerated MAFET program phase down with anticipated completion by the end of FY 1999, and SBIR reprogramming.

FY 2000

Decrease reflects completion of the composite CAD program, Smart Module program and the transition of the Centers of Excellence to state/private support.

FY 2001

Increase reflects initiation of the Mixed Technology Integration program and initiation of major MEMS integration program.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE					September 1998
RDT&E, Defense-wide					Advanced Electronics Technologies					
BA3 Advanced Technology Development					PE 0603739E, Project MT-03					
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
*Uncooled Integrated Sensors MT-03	8,289	11,000	3,000	0	0	0	0	0	0	N/A

\*Formerly titled IR Focal Plane Array

(U) Mission Description:

(U) The Uncooled Integrated Sensors project addresses the technology necessary to produce affordable, infrared (IR) sensor arrays, essential to major weapon systems. The focal plane array consists of a two-dimensional detector array sensitive in a broad spectral range, integrated with unique signal processing to enhance performance and provide more efficient utilization of the information. The critical elements of the technology addressed in this program include the infrared material, detector array fabrication, read-out electronics, cryogenic packaging and testing, and module assembly. Processing and fabrication techniques focus on the production of affordable arrays, at low volume, in the configurations required by weapon systems. Performance enhancements in uncooled infrared and near-infrared sensors are also being addressed to provide an integrated, broadband two dimensional sensor array without the cryogenic package usually associated with infrared sensors. Elimination of the cryogenic package dramatically reduces the cost of the sensor module, and provides a sensor package compatible with a wide range of system applications, including navigation, targeting and manportable systems. The solid state integrated sensor also solves the problem of blooming in the presence of high intensity sources, which is encountered with current low light level visible and near infrared sensors. Arrays will be built in the configuration required for missile seekers, target acquisition and navigational platforms, search and track, and threat warning systems.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Demonstrated uncooled infrared array with thermal sensitivity of 0.05 degrees. (\$ 3.289 Million)
- Demonstrated low light level solid state imager with anti-blooming protection. (\$ 5.000 Million)

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RDT&E, Defense-wide		Advanced Electronics Technologies	
BA3 Advanced Technology Development		PE 0603739E, Project MT-03	

(U) FY1999 Plans:

- Fabricate and test integrated uncooled infrared array and solid state, low light level array with anti-blooming protection. (\$ 7.000 Million)
- Establish feasibility of a solid state imager with spectral response beyond night vision goggles. (\$ 4.000 Million)

(U) FY2000 Plans:

- Demonstrate integrated imaging, consisting of 480 X 640 uncooled infrared fused with solid state low light level sensor, with performance required for man-portable systems and smart munitions. (\$ 2.100 Million)
- Demonstrate 480 X 640 monolithic uncooled infrared sensor with one pixels, demonstrating a five times increase in the sensitivity of uncooled sensors. (\$ 0.900 Million)

(U) FY2001 Plans: Not Applicable.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Sep 98	Evaluation of large area uncooled sensor with less than 0.05 degree thermal sensitivity.
Jan 00	Evaluation of integrated sensor with broad band infrared response.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE					September 1998
RDT&E, Defense-wide					Advanced Electronics Technologies					
BA3 Advanced Technology Development					PE 0603739E, Project MT-04					
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Electronic Module Technology MT-04	66,732	68,892	61,142	47,395	53,999	81,363	84,925	86,925	Continuing	Continuing

(U) Mission Description:

(U) The Electronic Module Technology Project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog, and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards and emerging technologies such as high density Multichip Modules (MCMs).

(U) The project has four major objectives: (1) shorten the overall design, manufacture, test, and insertion cycle for advanced electronic subsystems; (2) advance the state-of-the-art in electronic interconnection and physical packaging technology to allow circuits to operate close to their intrinsic maximum speed with less overhead in terms of volume, weight and cost; (3) provide a robust manufacturing infrastructure for electronic modules; and (4) demonstrate the system level payoff of electronic module technology through advanced technology demonstrations (ATDs).

(U) The project has the following major elements: Photonic Analog/Digital (A/D) Conversion; Optical Micro-Networks (OMNET); Distributed Robotics; Design Support for mixed Technology Integration (Composite CAD) and the Molecular-Level Large-Area Printing (MLP) program. OMNET seeks to demonstrate new paradigms for integrating electronic, electromechanical, and electro-optical components to enable small, lightweight, battlefield information systems. Distributed Robotics is a new effort to integrate developments in MEMS, power sources, communications, and advanced microelectronics to design, construct and field multiple, high-performance, mobile, autonomous systems. Composite CAD seeks to develop the design tools (concept exploration, analysis, optimization and verification) to allow thousands of analog, digital, optical, MEMS and microfluidic devices to be integrated into "systems-on-a-chip" and other highly integrated mixed technology systems. The MLP program is exploring approaches to 'print' MEMS devices on large surfaces.

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BA3 Advanced Technology Development		PE 0603739E, Project MT-04	

(U)

Program Accomplishments and Plans:

(U)

FY1998 Accomplishments:

•

Completed ASEM program that reduced non-recurring engineering costs for designing and inserting multi-chip modules. (\$ 6.300 Million)

•

Completed the Multichip Integration (MCI) program that improved substrate fabrication, demonstrated reductions in Multichip Modules (MCM) manufacturing costs, and technology insertions. (\$ 14.300 Million)

•

Optical Micro-Networks (OMNET) - Downselected amongst heterogeneous integration technologies and demonstrated multi-functional integration of electronic, electro-mechanical and optoelectric components targeted to military information systems. (\$ 12.700 Million)

•

Distributed Robotics - Initiated effort to put together, in one package, low-weight (<2 kg), high-performance payloads including sensors, imagers, countermeasures, designators, communications, and munitions. (\$ 8.800 Million)

•

Composite CAD - Integrated a composable design capability for single chip electronics and MEMS systems. Developed models with parameters optimized for manufacturing variances. Initiated behavior modeling of mixed technology devices. (\$ 15.900 Million)

•

Molecular-level, Large-area Printing (MLP) - Established preliminary micro-molding process using commercially available (CD manufacturing) tool; initiated studies of alternative micro-printing processes (letterpress, gravure, and tropomorphic). (\$ 8.732 Million)

(U)

FY1999 Plans:

•

OMNET - Demonstrate integrated optoelectronic transceivers and optical switches for reconfigurable interconnections of sensors to processors and the ability to distribute computation across military platforms 1-100 meters in length for future Electronic Warfare/digital radar and image processors. (\$ 13.000 Million)



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BA3 Advanced Technology Development		PE 0603739E, Project MT-04	

- Distributed Robotics - Construct the unit platforms, integrate commercial or demonstrated technology elements (e.g., imagers, MEMS, wireless systems), and define multiple, cooperative functions for selected military applications. (\$ 13.000 Million)
  - Composite CAD - Continue to develop the mixed domain software (kinematic, electric, electrostatic, and fluidic) analysis of micro-machined devices, systems of devices and corresponding electronic circuits to support the design of composite electronic sensors and systems. (\$ 21.900 Million)
  - Photonic A/D - Initiate photonic A/D converter development to achieve breakthrough in high speed A/D conversion. (\$ 9.000 Million)
  - MLP - Complete experimental characterization of release agents for micromolding; select candidate printing processes ( $\leq 2$ ) and compatible readout process for development; and demonstrate writing on non-flat surfaces with radii of curvature in the range 1m to 1cm. (\$ 11.992 Million)
- (U) **FY2000 Plans:**
- Photonic A/D - Demonstrate key optical clock, optical sampler and related optical technologies for photonic A/D converters operating in the 10-100 Giga sample per second range and identify high impact applications for this technology. (\$ 16.100 Million)
  - Distributed Robotics - Demonstrate feasibility of a variety of different robots (<5cm) to operate in specific military environments and their ability to adapt to varying environments and missions. Initiate effort to develop millimeter sized robots. (\$ 20.000 Million)
  - Composite CAD - Complete the development of systems software design and simulation capabilities for mixed technology micro-systems, including MEMS-enable designs and microfluidic (Micro-Flumes) designs. The ultimate goal of the complete systems design capability is to enable mixed technology systems-on-a-chip. Provide mixed technology design libraries, models, and test structure data to improve design quality, development time, and ability to reuse designs. (\$ 11.000 Million)
  - MLP - Concentrate on the development and choice of non-conventional large-area, MLP techniques for a demonstration system. (\$ 14.042 Million)

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(U) **FY2001 Plans:**

- Photonic A/D - Complete initial photonic A/D converter evaluation and finalize design for demonstration module. (\$ 16.500 Million)
- Distributed Robotics - Develop prototype millimeter sized robots using fundamental behavioral control mechanisms for sensing and communicating. (\$ 15.000 Million)
- Molecular-level, Large-area Printing - Concentrate on the demonstration of the use of MLP for realizing a wide area, super-high-resolution (e.g. 100-megapixel, corresponding to about 1,000 TV images) imaging system as needed, for example, for automatic threat warning. (\$ 15.895 Million)

(U) **Other Program Funding Summary Cost:** Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Sep 98	Demonstrate MCM substrates with integrated passive components.
Jul 99	Demonstrate mixed energy domain analysis capability for integrated technology devices.
Aug 99	Demonstrate optical micronetwork with reconfiguration capability.
Nov 99	Initial prototype of tightly integrated adaptive payload technology.
Apr 00	Characterization of single crystal semiconductors on amorphous surfaces.
Jun 00	Establish overlay capabilities for MLP.
Sep 00	Design and initiate fabrication of demonstration sensor array.
Sep 00	Demonstrate initial PCM designs (<10 femtosecond jitter, 100 on W output).

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide					Advanced Electronics Technologies						
BA3 Advanced Technology Development					PE 0603739E, Project MT-05						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Tactical Information Systems MT-05	28,328	36,596	19,640	22,748	21,100	0	0	0	0	NA	

(U) Mission Description:

(U) This project is a major DoD effort to develop the technology for displays and portable information systems for use in a variety of military systems. The project has two major efforts: Smart Modules and Warfighter Visualization. Smart Modules will design, develop, and integrate prototype modules, using core technologies that sense, think, and communicate into selected personal information products. Warfighter Visualization efforts demonstrate the feasibility of combining real-time visual images of the environment with geospatially registered computer-generated information for use by individual mounted and dismounted warfighters.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Demonstrated prototype electronic countermeasures system integrated into a soldier worn vest. The computational capability developed in the FY 1997 program was augmented with two PC cards containing ECM circuitry that allowed dismounted soldiers to instantly locate radio emissions from hostile forces. Demonstrated a prototype waterproof computer for underwater use in SEAL and Explosive Ordnance Disposal applications. (\$ 14.200 Million)
- Continued efforts to develop hand and head motion tracking technologies. Tracking head movement will allow a computer to display information to a head mounted display that is registered in the geospatial direction that the individual is looking. Tracking hand motion will allow a computer to recognize pointing and gestures as input mechanisms instead of using a keyboard. (\$ 6.400 Million)
- Demonstrated image capture and geospatial registration of icons on terrain in a moving vehicle. The vehicle was equipped with video cameras that provided a 360 degree view. Inside the vehicle, a person wearing a head tracked, head mounted display was able to look

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around and view the images obtained from the cameras. Icons and graphical images generated by a computer were overlaid on the camera image in the head mounted display. These images were registered with the viewed real-world terrain. (\$ 7.728 Million)

(U) FY1999 Plans:

- Demonstrate a novel capture device that incorporates signal and data processing in a 3-D package for use by individual soldiers. This miniature device, weighing only a few ounces, will be able to capture an image and rapidly analyze movement or correlate images with all processing done on the focal plane. The camera will be able to be worn by individual soldiers and communicate via a radio to and from geographic information system databases. (\$ 9.200 Million)
- Demonstrate a wearable computer incorporating wireless communication in a one pound, one watt configuration. This represents a 3x improvement in weight and a 10x improvement in power over current technology. The wearable computer will be used in a wide variety of space applications by the small unit operations soldier. (\$ 9.900 Million)
- Demonstrate prototype capability for dismounted soldiers to view the real world with overlaid graphic symbology. This capability will allow the soldier to receive visual information that is relevant to his/her mission time or location. It will also allow the soldier to interrogate databases containing information about the specific objects in his/her viewing environment. (\$ 5.800 Million)
- Demonstrate prototype "see-through" tank concept. This capability will allow a "buttoned-up" tank crew wearing head mounted displays to view the outside world as though the tank were made of glass. This will be accomplished by placing cameras on the outside of the tank that provide inputs to a mapped memory. Images will be fed to the user's head mounted display depending upon the direction that the user is looking. This capability will significantly enhance the situation awareness of the tank crew. (\$ 6.500 Million)
- Demonstrate a capability to obtain one dimensional and two dimensional data from a submarine sensor suite and configure these data into a 3-D image covering 360 degrees that is provided to a head tracked, head mounted display. This capability will be used by a submarine conning officer to demonstrate an enhanced capability for under ice submarine navigation. (\$ 5.196 Million)

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(U)

**FY2000 Plans:**

- Warfighter Visualization:

- Demonstrate a non-metallic tracking system for mounted and dismounted soldiers. System gives accurate low lag estimates of head position and pose for body oriented battlefield visualization. System is necessary for visual data correlation system, and see through combat vehicle applications. (\$ 3.300 Million)
- Develop a two-chip image processing system for integration into battlefield smart camera. This system will shrink multiple electronics boards into a small enough package for applications in night vision goggles, UAV surveillance, and headworn image stabilization. (\$ 4.300 Million)
- Demonstrate a prototype supernormal listening system for enhanced battlefield awareness. This system will enhance hearing capability and improve situation awareness and voice communications in both quiet and loud ambient noise environments. (\$ 3.600 Million)
- Demonstrate a prototype optical tracking system using bodyworn camera. This system will give position coordinates in environments where GPS is unavailable, and give more accurate position coordinates where it is available. This capability is essential for urban and in-building small-unit operations. (\$ 4.600 Million)
- Demonstrate prototype high resolution single chip tactile display system. System will give 10X lower power and 100X higher resolution than existing tactile systems for covert battlefield alert and monitoring. Tactile display on gun, for example, will indicate number of rounds left in magazine using sense of touch. (\$ 3.840 Million)

(U)

**FY2001 Plans:**

- Warfighter Visualization:

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- Demonstrate a two camera prototype image sensor system giving high resolution imaging over 360 degrees with low delay. This system is essential for the realization of a cost-effective "see through" vehicle. (\$ 5.600 Million)
- Demonstrate an experimental low cost, lightweight perimeter monitoring system for dismounted soldiers. System creates a protection "dome" around sleeping soldiers to alert against intruders. (\$ 4.100 Million)
- Demonstrate a single chip localization system for battlefield awareness. Chips use time of flight measurements and triangulation to determine spatial coordinates while maintaining low probability of detection. (\$ 5.000 Million)
- Demonstrate a prototype bodyworn 3-D mission re/planning tool. System allows virtual "walk through" of operations area and real-time editing. System also gives visualization of dynamic multi-sensor I/O on the battlefield. (\$ 4.600 Million)
- Demonstrate an automated system for 3-D model-extraction from ground level video. System builds up 3-D models for mission planning "walk throughs" using views from vehicles, robots, UAVs and other sources. (\$ 3.448 Million)

(U)

Other Program Funding Summary Cost: Not Applicable.

(U)

Schedule Profile:

Plan	Milestones
Feb 99	Demonstrate 1 pound, 1 watt wearable computer system.
Feb 99	Real world viewing with computer generated graphic overlay demonstration.
Dec 99	Build and test Advanced Humanistic Platform prototype.
Dec 99	Develop hybrid sensor tracking features and including "smart camera" functions to allow collaborative updates between soldiers.
Jul 00	Develop real-time visual data correlation system in dismounted and mounted warrior applications.
Jul 01	Demonstrate dynamic multi-sensor I/O in both dismounted and mounted military applications.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide					Advanced Electronics Technologies						
BA 3 Advanced Technology Development					PE 0603739E, Project MT-06						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Microwave and Analog Front End Technology MT-06	17,543	4,000	0	0	0	0	0	0	0	N/A	

(U) Mission Description:

(U) Microwave and millimeter wave technology for DoD electronic weapon systems is at a critical crossroads. Great progress has been made under the microwave and millimeter wave integrated circuit (MIMIC) program in terms of maturing the gallium arsenide industrial community. The DoD is now far ahead of the commercial world in microwave and millimeter wave technology in terms of performance characteristics. However, in many cases, radio frequency (RF) sub-system costs are still a major impediment to fielding DoD weapon systems. Material, processes and design technology advances must be undertaken to sustain an effective defense capability and to maintain U.S. dominance in this critical technology area. The MAFET program has addressed this problem by: (1) reducing design time and cost for every RF system being developed or upgraded through an improved microwave/millimeter wave design environment; (2) breaking the very expensive cycle and time-consuming current practice of design-build-test--redesign-rebuild-retest; (3) establishing repeatable, robust processes to produce high frequency components; (4) making strategic investments in critical passive, packaging and integrated circuits devices needed for millimeter wave systems; and (5) investigating revolutionary solutions to the long-standing problem of insufficient power in solid-state radar and communications transmitters.

(U) Program Accomplishments and Plans:(U) FY1998 Accomplishments:

- Completed microwave/millimeter wave computer aided design environment. Demonstrated design environment effectiveness. Continued implementation of Microwave Hardware Description Language (MHDL). (\$ 6.000 Million)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA 3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies	September 1998
	PE 0603739E, Project Microwave and Analog Front End Technology MT-06	

- Completed advanced sensor technology developments in the areas of: advanced fabrication, packaging, and multichip assembly (MCA) foundries. In the fabrication area, demonstrated: (1) production InP HEMT and HBT millimeter wave processes; (2) advanced manufacturing processes for: high power and high efficiency, and high dynamic range, capability; and (3) highly manufacturable and reliable HBT high power amplifiers. In the packaging area, demonstrated: (1) a 10x cost reduction in plastic HDI module fabrication technology; and (2) a 7x RF interconnect/package reduction due to embedded transmission lines and advanced multilayer interconnect. In the foundry area, demonstrated a 5x reduction in MCA production cost. (\$ 5.200 Million)
- In novel high-power transistor area, demonstrated 5-W SiGe HBT solid-state power amplifier (SSPA) having near-50 percent power-added efficiency (PAE) at X-band; demonstrated 10-W GaN MODFET having PAE=50 percent in X band; demonstrated 25-W SiC MESFET having PAE=45 percent in X band. (2) In quasi-optics area, continued development of solid-state quasi-optical Ka-band sources with high output power and high coherence; completed and demonstrated numerical design tool. (3) In MEMS-switch area, demonstrated 4-bit true-time-delay phase shifter in (a) X-Band with 2-dB total loss, and (b) Ka-Band with 3-dB loss; demonstrated 20/44-GHz dual-frequency MEMS-switched planar antenna. (4) In micromachined circuits and novel thermal management area, demonstrated micromachined W-band Wilkinson combiners in Si substrates; demonstrated Flourinert cooling of a 10-W X-band MMIC and a 1-W Ka-band MMIC. (\$ 6.343 Million)

(U) **FY1999 Plans:**

- In quasi-optics area, demonstrate a set of quasi-optical grid-, array-, card-, and slab-combined power amplifiers including (a) a 100-W 50 percent-PAE card amplifier at 10 GHz, (b) a 20-W-output >25 percent-PAE array amplifier at 35 GHz, (c) a 20-W-output 15-to-20 percent-PAE grid amplifier at 40 GHz, (d) a 10x10-element 10-W electronically-steerable array amplifier at 44 GHz, and (e) a 5-W 20 percent-PAE slab-amplifier at 94 GHz. (\$ 2.000 Million)
- In MEMS-switch area, demonstrate MEMS-tunable Chebyshev filter operating at 20 and 45 GHz; demonstrate MEMS-array transmitting beam-steerer at 44 GHz. (\$ 1.000 Million)

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- In micromachined circuits and novel thermal management area, demonstrate a micromachined SSPA ("W-Band Power Cube") having 2 W/in<sup>2</sup> intensity radiated from top facet. The power cube will be fabricated with InP Power MMICs that are thermally managed by bump bonding and are coupled to free space by Si-micromachined feed-line and planar-antenna structures. (\$ 1.000 Million)

(U) FY2000 Plans:

- Not Applicable.

(U) FY2001 Plans:

- Not Applicable.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Sep 98	Ultra-low-cost SiGe T/R modules.
Dec 98	Demonstrate 10-W millimeter wave power amplifier array.
Jan 99	Demonstrate millimeter wave micromachined solid-state power amplifier.
Mar 99	Demonstrate millimeter wave beam steering module.
Jun 99	Demonstrate > 100-W low cost X-band electronically steerable source.
Sep 99	Demonstrate full interoperability of CAD vendors.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide					Advanced Electronics Technologies						
BA3 Advanced Technology Development					PE 0603739E, Project MT-07						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Centers of Excellence MT-07	4,844	4,000	0	0	0	0	0	0	0	N/A	

(U) Mission Description:

(U) This project provides funding for the Robert C. Byrd Institute for Advanced Flexible Manufacturing at Marshall University and the Defense Techlink Rural Technology Transfer Project. The Byrd Institute provides both a teaching factory and initiatives to local area industries to utilize computer-integrated manufacturing technologies and managerial techniques to improve manufacturing productivity and competitiveness. Training includes technologies to significantly reduce unit production and life cycle costs and to improve product quality.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Completed development of internetting capabilities at the Institute for Advanced Flexible Manufacturing to ensure medium- and small-sized businesses have access to emerging electronic commerce and advanced technologies. (\$ 3.844 Million)
- Congressional add provided funding for the Defense Techlink Rural Technology Transfer Project. (\$ 1.000 Million)

(U) FY1999 Plans:

- Complete assessment of the Institute for Advanced Flexible Manufacturing's performance and transition from DoD to state/private support. (\$ 4.000 Million)

(U) FY2000 Plans: Not Applicable.

(U) FY2001 Plans: Not Applicable.

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(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan                      Milestones

Oct 98

Demonstrate advanced internetting capabilities that can be utilized by medium- and small-sized businesses to access emerging electronic commerce and advanced technologies.

Oct 99

Complete assessment and transition of the Institute from DoD to state/private support.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide					Advanced Electronics Technologies						
BA3 Advanced Technology Development					PE 0603739E, Project MT-08						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Manufacturing Technology Applications MT-08	26,175	22,200	20,253	0	0	0	0	0	0	N/A	

(U) Mission Description:

(U) Future military systems will be affordable only if the manufacturing process is considered as an integral part of product design, production takes place in flexible, multi-product factories, and if advanced manufacturing technology is combined effectively with advanced business practices. This program focuses on demonstrations of process technology combined with innovative industrial practices and will measure the improvements in cost, schedule and quality achievable in key defense product areas.

(U) The Affordable Multi-Missile Manufacturing (AM3) program is an Advanced Technology Demonstration initiated in FY 1995. The objective of AM3 is to demonstrate the feasibility of 25-50 percent reductions in the unit cost of tactical missiles, both in ongoing missile production programs and in new missiles and major modifications. This will be accomplished by teams of missile prime contractors, component suppliers and manufacturing equipment and software vendors who develop and demonstrate the combined effects of advanced design, manufacturing, assembly systems and processes, missile value engineering changes, and acquisition reform and business practice innovations. A major technical theme is to achieve economies across a mix of missiles to compensate for the decline in individual missile quantities. Demonstrations will be conducted in the design and manufacture of components and guidance and control/seeker assemblies for multiple missiles, including R&D and production programs.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Affordable Multi-Missile Manufacturing (AM3). (\$ 21.372 Million)
  - Began AM3 Phase 3 implementation of new factory systems and new business practices.
  - Completed initial design and test planning for AM3 multi-missile components and value engineering change proposals.
  - Completed initial demonstrations of supply chain technologies to fill gaps identified in AM3 Phase 1, and continued technical integration and independent cost analysis.

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- Interferometric Fiber Optic Gyroscope (IFOG). (\$ 4.803 Million)
  - Demonstrated flexible production of navigation grade and tactical grade IFOG units.
  - Demonstrated production of high power, stable, packaged optical sources, low cost couplers and wavelength division multiplexers.
  - Improved Magnetic Field & temperature sensitivity of IFOG Instruments further improved packaging and tests for low cost performance.

(U) **FY1999 Plans:**

- Affordable Multi-Missile Manufacturing. (\$ 22.200 Million)
  - Continue AM3 Phase 3 implementation of flexible multi-product assembly cells and prototype production of missile hardware.
  - Conduct initial tests of missile seekers built with the Affordable Multi-Missile Manufacturing scalable family of parts and commercial components.

(U) **FY2000 Plans:**

- Affordable Multi-Missile Manufacturing. (\$ 20.253 Million)
  - Complete integration of flexible factory assembly areas. Deploy System Integrated Design Environment. Complete design and prototype fabrication of low cost IMU. Complete common processor design verification test and integration. Validate electronic collaborative tools and complete supplier affordability demonstration. Complete integration of guided flight unit, gyro optics assembly fabrication, and mid-body casting demonstration.
  - Complete common seeker commercial parts test evaluation, producibility analysis, and flight test. Complete common IMU design verification test, prototype demonstration unit, and technology insertion review. Complete process design for flexible multi-product assembly cells, validate on production parts, and demonstrate on production line. Complete electronic procurement and supplier integration demonstrations.

(U) **FY2001 Plans:** Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-08	September 1998

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Dec98	Complete Wavelength Multiplexer and coupler cost reduction and demonstrate Production
Apr99	Complete IFOG performance and variability reduction activities.
Oct 99	Complete integration of flexible factory assembly areas.
Oct 99	Complete common seeker commercial parts test evaluation, producibility analysis, and flight test.
Dec 99	Complete AM3 Phase 3 multi-missile manufacturing demonstrations.
Jan 00	Deploy System Integrated Design Environment.
Jan 00	Complete common inertial measurement unit design verification test, prototype demonstration unit, and technology insertion review.
Mar 00	Complete common processor design verification test and integration.
Mar 00	Complete process design for flexible multi-product assembly cells, validate on production parts, and demonstrate on production line.
Jun 00	Complete flight tests of AM3 missile seeker prototypes.
Jul 00	Complete integration of guided flight unit, gyro optics assembly fabrication, and mid-body casting demonstrations.
Jul 00	Complete electronic procurement and supplier integration demonstrations.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide					Advanced Electronics Technologies						
BA3 Advanced Technology Development					PE 0603739E, Project MT-10						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Advanced Lithography MT-10	49,710	26,500	28,000	24,000	27,500	24,754	24,754	24,754	Continuing	Continuing	

(U) Mission Description:

(U) Microelectronics is a key to improved weapon system performance and lithography technology has enabled the dramatic growth in microelectronics capability over the past three decades. The improved capabilities in semiconductor technology contribute to significant system gains in speed, reliability, cost, power consumption, and weight. Advanced microelectronics technology is essential for computing and signal processing in virtually all military systems including command, control, communications, and intelligence; electronic warfare; and beam forming for radar and sonar. Further improvements in areas such as target recognition, autonomous guided missiles, and digital battlefield applications require microcircuits with smaller features to meet the operational speed, power, weight and volume constraints of these systems.

(U) Current microelectronics fabrication utilizes feature sizes of 0.35 microns. The Advanced Lithography Program emphasizes longer-term research with expected high payoff in the fabrication of semiconductor devices with 0.1 or less micron feature sizes. These programs will develop technology for sub 0.1-micron features. Current programs in crosscutting technologies (mask, stages, resists, metrology) and x-ray lithography will be completed in one to two years. Key subsystems of the maskless e-beam developments will be demonstrated late in the decade.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Researched efforts for sub 0.1 micron in maskless lithography (emitter arrays and photocathodes), innovative imaging materials, and network of university efforts in novel patterning. (\$ 19,400 Million)
- Completed development of crosscutting technology in precision stages and mask making (e-beam writing and inspection) for 0.13 - 0.10-micron features. (\$ 6,200 Million)
- Completed point-source x-ray lithography program. (\$ 2,800 Million)

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- Continued funding of the Lithographic and Alternative Semiconductor Processing Techniques (LAST) Center to develop mask technology for semiconductor device fabrication. (\$ 16.700 Million)

- Continued Laser Plasma x-ray source technology. (\$ 4.610 Million)

### (U) FY1999 Plans:

- Continue efforts in maskless lithography, including arrays of miniature e-beam columns, and novel imaging materials and pattern transfer processes.
  - Continue network of university efforts in novel patterning. (\$ 9.500 Million)
  - Complete column test stand for maskless e-beam writer. (\$ 17.000 Million)

### (U) FY2000 Plans:

- Continue maskless lithography techniques for lower cost, low volume production. Develop smaller features for semiconductor devices for better performance. Develop improved metrology for ultra-small devices. (\$ 28.000 Million)

### (U) FY2001 Plans:

- Demonstrate maskless writer and characterize performance. Continue support technology developments in metrology, resist materials, and improved stage control applicable to 0.05-micron design rules. (\$ 24.000 Million)

- (U) Other Program Funding Summary Cost: Not Applicable.

### (U) Schedule Profile:

<u>Plan</u>	<u>Milestones</u>
Jun 99	Demonstrate switched emitter arrays for maskless lithography.
Jul 00	Demonstrate ion microcolumn for maskless lithography.
Mar 01	System demonstration of maskless charged particle writer.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide					Advanced Electronics Technologies						
BA3 Advanced Technology Development					PE 0603739E, Project MT-12						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Microelectromechanical Systems (MEMS) MT-12	70,555	71,549	78,979	80,000	79,000	88,300	96,300	93,300	Continuing	Continuing	

(U) Mission Description:

(U) The Microelectromechanical Systems (MEMS) program is a broad, cross-disciplinary initiative to develop an enabling technology that merges computation with sensing and actuation to realize new systems for both perceiving and controlling weapons systems, processes, and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiple components, and integrated microelectronics to the design and construction of integrated electromechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. The microfluidic molecular systems program will address issues centered around the development of automated microsystems that integrate biochemical fluid handling capability along with electronics, optoelectronics and chip-based reaction and detection modules to perform tailored analysis sequences for monitoring of environmental conditions, health hazards, and physiological states.

(U) The MEMS program has three principal objectives: the realization of advanced devices and systems concepts; the development and insertion of MEMS products into DoD systems; and the creation of support and access technologies to catalyze a MEMS technology infrastructure. These three objectives cut across a number of focus application areas to create revolutionary military capabilities, make high-end functionality affordable to low-end systems, and extend the operational performance and lifetimes of existing weapons platforms. The major technical focus areas for the MEMS program are: 1) inertial measurement; 2) fluid sensing and control; 3) electromagnetic and optical beam steering; 4) mass data storage; 5) chemical reactions on chip; 6) electromechanical signal processing; 7) active structural control; 8) analytical instruments; and 9) distributed networks of sensors and actuators.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY		R-1 ITEM NOMENCLATURE	September 1998
RDT&E, Defense-wide		Advanced Electronics Technologies	
BA3 Advanced Technology Development		PE 0603739E, Project MT-12	

(U) Among the many accomplishments to date are: a wind-tunnel test of an integrated MEMS sensor and actuator array distributed along the leading edge of a model aircraft wing creating rolling moments of sufficient strength to control aircraft flight, pointing the way to future fighter aircraft with advanced maneuverability unattainable using conventional, large and discrete control surfaces; a demonstration of a MEMS-based accelerometer capable of surviving and operating in the near 100,000 G accelerations generated by firing artillery shells, making possible affordable guidance systems to what are presently unguided munitions and increasing both their effectiveness and life cycle costs; and the establishment of a regularly scheduled, shared, MEMS fabrication service for domestic DoD, commercial and academic users. The MEMS program has initiated new efforts in: low power miniaturized communications systems; distributed control aircraft roll and yaw; microscale power; micro airborne sensor/communication systems; data storage; and inertial systems.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Devices and Processes - Accelerated and expanded on MEMS system developments that exploit physics and MEMS systems architecture to project micro-scale actions into macro-scale effects such as micro-optomechanical scanners, switches, displays, adaptive optics and aligners. (\$ 19.000 Million)
- System Design and Development - Extended present fabrication processes to cost-effective, large area fabrication approaches. (\$ 22.600 Million)
- Support and Access Technologies - Integrated developments in MEMS, robotics and ultra-electronics to design, construct and field multiple, high-performance, mobile, autonomous systems. (\$ 8.600 Million)
- Microfluidics - Initiated system-level integration through an evolving testbed strategy in which the development of new microfluidic components and processes occurred concurrently with the integration of early prototypes with available chip-based molecular analysis components. Leveraged analysis and detection technology from industry, Services, and other DoD programs when compatible with microsystems integration. (\$ 16.655 Million)
- Continued efforts at Center for Advanced Microstructures Devices (CAMD). (\$ 3.700 Million)

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(U) **FY1999 Plans:**

- MEMS Devices and Processes - Demonstrate radio-frequency electromechanical signal processing; MEMS-based mass data storage; massively parallel read/write structures; micro thrusters for satellite attitude, propulsion and control. (\$ 10.000 Million)
- MEMS System Design and Development, Phase I - Initiate concept demonstrations for systems in the form of aerodynamic control of model aircraft; low-power wireless integrated microsensors; miniaturized foresites for fuze, safe, and army. (\$ 25.500 Million)
- MEMS Systems Design and Development, Phase II - Initiate concept demonstrations for microsensors for structural health, maintenance, and monitoring; gas-phase microinstruments; polymer-based MEMS; micro power sources. (\$ 20.000 Million)
- Microfluidics - Demonstrate a microfluidic sensor system capable of indicating specific DNA hybridization events. Demonstrate detection of pathogens or protein molecules without requiring reporters by using coated beads and DEP/FFF/IS (dielectrophoresis-field flow fractionation-impedance sensor). Demonstrate prototype microfluidic system to reconstitute a 20-ml volume of lyophilized material in one minute to five percent reconstitution accuracy using thermocapillary pumping and mixing. (\$ 10.000 Million)
- Microfluidics - Demonstrate automated isothermal DNA analyzer: multichannel, microchip device with integrated aerosol collector. Demonstrate portable biodetector prototype with sensitivity for three types each of bacteria, viruses and toxins as well as sensitivity to unknown toxicants by cell or coated beads. (\$ 6.049 Million)

(U) **FY2000 Plans:**

- MEMS Insertions - Merge sensing, computing and actuating to realize new systems and strategies. These new approaches will bring new perception and control functions to weapons and battlefield environments. Program is in its third phase, systems demonstrations and insertion, including: Microassembled electromechanical signal processing; MEMS aerodynamic pressure sensors on flexible, adhesive tape substrate; Modular, monolithically integrated MEMS IMU; and MEMS high-temperature sensor and actuator arrays. (\$ 29.3 Million)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development		R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-12	September 1998

- MEMS Integration/Devices and Processes - Develop new devices and processes for heterogeneous integration of MEMS, including micro power sources, microprocessor units, micro actuators, and communication components. (\$ 19.000 Million)
- MEMS Integration/System Design and Development - Initiate concept demonstrations for systems in the form of "smart dust," micro airborne sensor/communicator platforms, and chemically powered remote sensors. (\$ 18.000 Million)
- MEMS Integration/Support and Access Technologies - Initiate demonstrations of MEMS microassembly, packaging, and fabrication at distributed sites for robust sourcing of Integrated MEMS systems. (\$ 12.679 Million)

(U) FY2001 Plans:

- MEMS Integration/Devices and Processes - Continue development of devices and processes for heterogeneous integration of MEMS, including micro power sources, microprocessor units, micro actuators, and communication components. (\$ 36.000 Million)
- MEMS Integration/System Design and Development - Perform concept demonstrations for systems in the form of "smart dust," micro airborne sensor/communicator platforms, and chemically powered remote sensors. (\$ 28.000 Million)
- MEMS Integration/Support and Access Technologies - Complete demonstrations of MEMS microassembly, packaging, and fabrication at distributed sites for robust sourcing of Integrated MEMS systems. (\$ 16.000 Million)

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(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

<u>Plan</u>	<u>Milestones</u>
Jan 99	Demonstrate MEMS-based mass data storage.
Mar 99	Demonstrate MEMS control of delta wing model aircraft.
Mar 99	Demonstrate scanning probe arrays for mass data storage.
Jun 99	Demonstrate multi-frequency, tunable RF and microwave filters, switches, and phase shifters.
Jun 99	Demonstrate local micro-encapsulation of inertial instruments.
Sep 99	Demonstrate distributed, multiple, and miniature thrusters for satellite propulsion and attitude control.
Mar 00	Demonstrate microassembled electromechanical signal processing.
Jun 00	Demonstrate miniature aerodynamic pressure sensors on a flexible, adhesive tape.
Jun 00	Demonstrate a modular, monolithically integrated IMU.
Sep 00	Demonstrate MEMS high-temperature sensor and actuator arrays.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide					Advanced Electronics Technologies						
BA3 Advanced Technology Development					PE 0603739E, Project MT-15						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Mixed Technology Integration	0	0	36,000	71,205	53,510	50,000	50,000	50,000	Continuing	Continuing	
MT-15											

(U) Mission Description:

(U) The goal of this Mixed-Technology Integration program is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems that will revolutionize the way individuals see, hear, taste, smell, touch and control their environment at-a-distance, a paradigm that addresses many of the present and future needs of the DoD. These 'wrist watch-size', low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. At the present time, systems are fabricated by assembling a number of mixed-technology components: microelectronics, microelectromechanical systems (MEMS), microphotronics, microfluidics and millimeterwave/microwave. Each technology usually requires a different level of integration, occupies a separate silicon chip and requires off-chip wiring, fastening and packaging to form a module. The chip assembly and packaging processes produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration mixed technologies to form batch-fabricated, mixed technology microsystems 'on-a-single-chip' or an integrated and interconnected 'stack-of-chips'.

(U) Microelectronics incorporates micrometer/nanometer scale integration and is the most highly integrated, low-cost and high-impact technology to date. Microelectronics technology has produced the microcomputer-chip that enabled or supported the revolutions in computers, networking and communication. This program extends the microelectronics paradigm to include the integration of heterogeneous or mixed technologies and thereby create a new class of 'match-book-size', highly integrated device and microsystem architectures. Examples of component-microsystems include low-power, small-volume, lightweight, microprocessors, microbots and microcommunication systems that will improve and expand the performance of the warfighter, military platforms, munitions and UAVs.

(U) The program includes the integration of mixed materials on generic substrates including glass, polymers and silicon. The program is design and process intensive, using 'standard' processes and developing new semiconductor-like processes and technologies that support the integration of mixed-technologies at the micrometer/nanometer scale. The program includes the development of micrometer/nanometer scale isolation, contacts, interconnects and 'multiple-chip-scale' packaging for electronic, mechanical, fluidic, photonic and rf/mmwave/microwave technologies. For example, a mixed-technology microsystem using integrated microfluidics, MEMS, microphotronics, microelectronics and

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microwave components could provide a highly integrated, portable analytical instrument to monitor the battlefield environment, the physical condition of a warfighter, the identity of warfighters (friend or foe) or the combat readiness of equipment. The ability to integrate mixed technologies onto a single substrate will drive down the size, weight, volume and cost of weapon systems while increasing their performance and reliability. The resulting technology developments will make it possible to sense, compute, communicate and effect the environment with small (match book-size), inexpensive components that can be deployed on ships, aircraft, combat vehicles, munitions and warfighters.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments: Not Applicable.

(U) FY1999 Plans: Not Applicable.

(U) FY2000 Plans:

- 3-D Imaging – Initiate program to create new device technology to acquire a 3-D image of a target by rapidly sampling an optical return with a 2-D staring array. (\$ 7.500 Million)
- Steered Agile Laser Beams – Initiate program to develop compact, light weight, man-portable, electronically steered lasers to replace large, heavy gimbal mounted lasers in lasercom links and smart weapon target designators. (\$ 7.000 Million)
- RF Lightwave Integrated Circuits (R-FLICS) – Initiate program to demonstrate with heterogeneous integration, lightwave technologies to route, control and process analog RF Signals in the 10-100 GHz range. (\$ 7.500 Million)
- Photonic Wavelength and Spatial Signal Processing (Photonic WASSP) – Initiate program to begin a major development in photonics, using both wavelengths – wavelength optics – as well as spatial attributes of light – bulk optics. (\$ 7.000 Million)

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- Heterogeneous Materials Integration on Silicon – Initiate an integration program that develops a tool kit of materials and processes for integration of multiple materials onto a single substrate. (\$ 7.000 Million)
- (U) **FY2001 Plans:**
  - 3-D Imaging – Develop a 2-D array out of avalanche photodiode devices with a low noise preamp. Key is in uniformity of the pixels since they must be operated at very high field to get sufficient amplification. (\$ 14.500 Million)
  - Steered Agile Laser Beams – Develop electronically steered laser beam technology for use in covert, anti-jam, high bandwidth battlefield communications - hand held ground-to-ground recon units, which are able to transmit images and geo-location data of targets, and for use in target designators for small unit operations in high threat environments. Develop beam steering and detection systems. (\$ 15.500 Million)
  - R-FLICS – Demonstrate high performance R-FLIC Components to 100 GHz bandwidth. Demonstrate integrated RFLIC functions such as channelizer with 10 GHz selectivity over 0–100 GHz bandwidth. (\$ 12.500 Million)
  - Photonic WASSP – Continue component development, integration, algorithms, architectures and sub-system functionality demonstrations. (\$ 17.500 Million)
  - Heterogeneous Material Integration – Continue integration of new material and processes into a single substrate that will drive system performance. (\$ 9.000 Million)
  - Micro Ultra Wide Band – Initiate development of a 0-3Ghz communication (radio) chip with range less than 1 km, using ultra-wide band approach for pulse generation. (\$ 2.205 Million)

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(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan      Milestones

Materials Integration:

- 2Q01 Incorporate low parasite Heterojunction Bi-Polar Transistors (HBT's) into a silicon circuit simulator.
- 4Q01 Incorporate 50 GHz low parasitic HBT on silicon.
- 4Q01 Incorporate high power amplifiers into circuit simulation.

3-D Imaging:

- 3Q00 Develop low defect density near infrared materials suitable for high speed imaging.
- 4Q00 Demonstrate detector test arrays with gain/bandwidth product capable of sub-nanosecond detection at long range.
- 2Q01 Integrate novel, high gain/bandwidth detector array with low noise electronics.
- 4Q01 Demonstrate 3-D imaging for long range target identification.

R-FLICS:

- 2Q01 Demonstrate High Performance R-FLIC Components to 100 GHz bandwidth.
- 4Q01 Demonstrate integrated RFLIC functions such as channelizer with 10 GHz selectivity over 0-100 GHz bandwidth.

Steered Agile Laser Beams:

- 4Q00 Develop and evaluate steering options.
- 4Q01 Develop prototype modules.

Micro Ultra Wide Band:

- 3Q01 Conduct military demonstrations with through-wall imaging arrays, local tags for asset management and microplatforms for sensor and communication subsystems.

Photonic WASSP:

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2Q00  
2Q00  
2Q01  
4Q01

Fabricate and demonstrate laser resonators based on spherical and torroidal concepts for whispering gallery optical modes.  
Demonstrate tunable wide band optical filters for multi-spectral filtering.  
Demonstrate lasers with new (spherical and torroidal) resonator designs.  
Demonstrate passive spatial optical elements at micrometer scale.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Maritime Technology PE 0603746E				
					DATE September 1998				
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Total Cost
Shipbuilding Technology MR-01	32,750	15,000	0	0	0	0	0	0	N/A

(U) Mission Description:

(U) The goal of the MARITECH Program is to preserve the U.S. shipbuilding industrial base by improving the industry's commercial competitiveness through advanced technology applications. For the Defense Department, a competitive shipbuilding industry optimizes Navy ship acquisition reform and allows realization of the Department's objective for affordable Navy ships. The goal of the DoD Acquisition Reform Program is to take advantage of the best commercial practices of industry and thereby achieve cost reductions of the ships and systems it purchases. Having operated exclusively in a protected domestic market, the U.S. shipbuilding industry has not implemented the best commercial processes necessary to compete in the international arena or to build affordable Navy ships. The government's attempt at acquisition reform, as it applies to ship acquisition, could fall short if U.S. shipyards are not commercially competitive. The key for acquisition reform is for the U.S. shipbuilding industry to attain global commercial competitiveness.

(U) MARITECH is a two-phased program that provides products and infrastructure for the near and long term. The near term effort enhances international competitiveness through the development of a portfolio of U.S. ship designs for the international marketplace and the build strategies for their competitive price and delivery. This effort is being enhanced by developing an infrastructure that includes the implementation of electronic communications and commerce throughout the industry, and by participating in an industry-wide forum for problem solving on a technical level.

(U) The long-term effort includes the infusion of innovative product technologies and process improvements that brings the capabilities of the U.S. shipbuilding industry above those of foreign shipyards. This will result in a larger share of the international market, and a self-sustaining, highly efficient U.S. shipbuilding industry. The Navy will be assuming all funding responsibility for MARITECH in FY 2000.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Maritime Technology PE 0603746E, Project MR-01	September 1998

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Completed Total Process Systems development projects initiated in FY 1997. (\$ 7.935 Million)
- Completed Advanced Business Practices development projects initiated in FY 1997. (\$ 11.895 Million)
- Completed development of standard data exchange translators for digital ship design and construction. (\$ 3.480 Million)
- Completed advanced technology development projects initiated in FY 1996. (\$ 3.931 Million)
- Completed Electronic Commerce and Computer Integrated Enterprise project commenced in FY 1996. (\$ 3.413 Million)
- Developed and initiated a long range national level, technology development strategy with National Shipbuilding Consortium. (\$ 1.520 Million)
- Continued to improve and provide support for National Shipbuilding Network (NSnet). (\$ 0.344 Million)
- Initiated Commercial Cruise Ship Study. (\$ 0.232 Million)

(U) FY1999 Plans:

- Initiate research projects in the following areas: Advanced Ship Production Processes; Advanced Product Design and Manufacturing Technologies; and Electronic Customer and Supplier Interaction. (\$ 15.000 Million)

(U) FY2000 Plans: Not Applicable.

(U) FY2001 Plans: Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Maritime Technology PE 0603746E, Project MR-01	September 1998

(U) Program Change Summary: (In Millions)

	<u>FY1998</u>	<u>FY1999</u>	<u>FY2000</u>	<u>FY2001</u>
Previous President's Budget	36.030	15.000	0.000	0.000
Current Budget	32.750	15.000	0.000	0.000

(U) Change Summary Explanation:

FY 1998 Decrease reflects SBIR reprogramming (\$1M), inflation savings (\$4M) and program repricing (\$1.8M).

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Sep 98	Complete development and test of integrated Product Data Environment for Shipbuilding.
Sep 98	Complete final 6 ship designs for International Commercial marketplace.
Sep 98	Complete 7 process and product technology development projects initiated in FY 1995.
Sep 98	Complete development of long range technology development strategy for US shipbuilding industry.
Dec 98	Complete test and evaluation of System Life Cycle Support Infrastructure Demonstration Project.
Jan 99	Initiate research projects for shipbuilding technology development.
Jul 99	Complete development of National Shipbuilding Information Infrastructure Protocols.
Jul 99	Complete prototype demo and development of commercialization plan for next generation PC-based system for Integrated Product and Process Development.
Sep 99	Complete remaining 3 process and product technology development projects.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE					September 1998
RDT&E, Defense-wide					Command, Control and Communication Systems					
BA3 Advanced Technology Development					PE 0603760E					
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	147,525	200,100	229,086	213,078	214,583	208,583	225,583	225,583	Continuing	Continuing
Command Control Information Systems CCC-01	65,219	88,700	105,446	104,534	96,734	98,034	107,034	108,034	Continuing	Continuing
Information Integration Systems CCC-02	82,306	111,400	123,640	108,544	117,849	110,549	118,549	117,549	Continuing	Continuing

(U) Mission Description:

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

(U) The Command and Control Information Systems project is developing the technologies necessary to facilitate joint campaign planning and control throughout the battlespace. The primary program in this project is the Joint Forces Air Component Command System (JFACC), which will revolutionize command and control of joint and coalition air forces through the incremental development, integration, evaluation, demonstration, and transition of technology and systems. Other programs addressed in this project includes: the Integrated Battlespace program, Information Assurance program, the Advanced ISR Management program, the Advanced Joint Planning (AJP) advanced concept technology demonstration, the Agent-Based Systems program, Project Genoa, Counter Trans National Threat program and the Commercial Awareness Initiative program.

(U) The Information Integration Systems project will develop the technologies necessary to ensure that the enhanced information required by battlefield combatants is available on a near real time basis. Programs addressed in this project include the Dynamic Multi-User Information Fusion (DMIF) program, the Dynamic Database (DDB) program, the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD), the Airborne Communications Node (ACN) program, the Command Post of the Future program, and Course of Action Analysis program.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communication Systems PE 0603760E	September 1998

(U)

<u>Program Change Summary: (In Millions)</u>	<u>FY1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>
Previous President's Budget	150.010	200.100	187.369	206.234
Current Budget	147.525	200.100	229.086	213.078

(U)

Change Summary Explanation:

FY 1998

Decrease reflects rephrasing of the BADD ACTD and SBIR reprogramming adjustments.

FY 2000-01

Increase reflects transition of Project Genoa from PE 0602702E, Tactical Technology, Project TT-03 and an increase to the Airborne Communications Node (ACN) program for completion of payload integration and bench tests.

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APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide					Command, Control and Communication Systems						
BA3 Advanced Technology Development					PE 0603760E						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Command Control Information Systems CCC-01	65,219	88,700	105,446	104,534	96,734	98,034	107,034	108,034	Continuing	Continuing	

(U) Mission Description:

(U) Recent military operations, e.g., Desert Storm and Haiti, demonstrated that current theater command, control, communications, intelligence/information systems, planning and rehearsal systems; and non-lethal weapon's capabilities lack the ability to support effective operations in diverse new arenas and scenarios ranging from desert heavy battle actions to urban areas with large civilian populations. Current capabilities do not provide real-time situational awareness, decentralized battle planning, rehearsal and execution capability, flexible interfaces or critical interoperable wide-area communications. The goals of the programs in this project are to build on an innovative architecture and infrastructure to enhance information processing, dissemination and presentation capabilities for the Commander by inclusion of information pertaining to enemy and friendly forces, providing a joint situational awareness picture and improving planning, decision-making and execution support capability and providing multimedia information interfaces and software to "on-the-move users". Integration of collection management, planning and battlefield awareness programs is an essential element of our strategy for achieving battlefield dominance through information systems.

(U) The Joint Forces Air Component Commander (JFACC) Program seeks to revolutionize command and control (C2) of joint and coalition air forces through the incremental development, integration, evaluation, demonstration and transition to the Warfighter of technology and systems which will enable new operational concepts for planning and execution that will significantly improve the responsiveness, efficiency and effectiveness of air operations. Key aspects of the program are: continuous near-real-time planning and execution with all tasks tied to a central strategy and embodied in a common plan representation; collaboration among distributed elements to achieve a high degree of integration through the echelons and across operations, intelligence and logistics; and end-to-end management of C2 operations including advanced capabilities for strategy development, target systems analysis, campaign assessment and resource planning. Key technologies include: centrally managed, multi-stage, concurrent plan generation; planning agents; intelligent resource scheduling techniques; dynamic resource reallocation algorithms; adaptive cueing tools; automated information routers; information tailoring and visualization tools and advanced collaborative and workflow management tools. These technologies will be applied to requirements that include: continuous mission planning processes that quickly anticipate and react to changes in guidance, threat situation, resource availability and synchronization needs; full integration of intelligence, logistics and operational activities to support strike operations and prioritized target nomination, information gathering and logistics support functions of the component commander; empowerment of cross functional planning teams to quickly respond to changes; and proper battlefield knowledge to support activities

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and decisions at multiple echelons. JFACC technologies, that support operational level decision making and information processing, will be interoperable with related DoD programs (e.g., Advanced Logistics Project (ALP) and Battlefield Awareness and Data Dissemination (BADD)). Program execution features a multi-phased, develop-demonstrate-transition approach, including close coordination with the Air Force and Navy Battlelabs, the Advanced Information Technology Services (AITS) Joint Program Office (JPO), and other service C2 organizations.

(U) With the growing dependence on information systems and the pressing need to be able to get the right information to the right person at the right time, it becomes critical to deliver and protect information and assure the availability of associated services -- particularly in a stressed environment. Information Assurance (IA) technologies will be integrated into future versions of the Defense Information Infrastructure (DII) Leading Edge Services (LES) to provide a robust architecture across a wide range of DoD information systems. The development and fielding of secure information systems will be a continuing process of development and upgrading of existing systems and capabilities. The program is developing and refining information security technology into the LES architecture and testbed. The resulting security framework will reduce information vulnerability, allow increased interoperability and functionality, and provide the operational commander greater assurance that he will have the information he needs when he needs it. The initial investment provides: near term applications to provide a modest level of protection and a mechanism to test advanced secure information development in an end to end environment.

(U) A new generation of collection systems will provide dramatically increased volumes of higher fidelity data to the operational decision-maker. The challenge will be to dynamically manage and synchronize this advanced collection architecture with the next-generation processing, exploitation, and dissemination capabilities to provide the critical information to the decision maker in the constantly changing operational situation. The Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM) project will expand on efforts begun under the JFACC program and provide the technical foundation for ISR support to Joint Vision 2010 through the development of Information Management, Collection Strategy Development, and Multi-asset Synchronization capabilities to dynamically optimize/synchronize, schedule, and task the spaceborne, airborne and ground based collection, processing, exploitation and dissemination architecture. The AIM project will optimize ISR support to precision engagement and dominant maneuver by providing proactive information support to the warfighter, continuous integration of Operations and ISR, responsive ISR timelines, optimal ISR confederation management, and synchronization of ISR asset and exploitation tasking. AIM's Information Management effort will insure near-real-time (NRT) information support to commanders and the Joint Task Force (JTF) by providing all echelons with: a common view of the collection environment; current status of collection, processing, exploitation, and dissemination operations; faster than real-time simulations in support of trade-off decisions; and the ability to conduct real-time multi-echelon coordination and shared decision making. AIM's Collection Strategy Development effort will interoperate with future automated operational plan representations to continuously interpret ISR requirements contained in the plan and decompose these requirements into discrete sensor, information retrieval, and exploitation tasks. AIM's Multi-Asset Synchronization effort will simultaneously plan and integrate platform routes and schedules that maximize

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the total information value from the ISR confederation in support of the operational plan. The AIM project will develop or advance technologies in the following areas: workflow management, multi-node collaboration, social computation, automated reasoning, mathematical programming, and cognitive representations. Resulting AIM capabilities will transition to DoD automated planning and C4ISR migration systems as appropriate.

(U) The Control of Agent-Based Systems Program will develop control strategies that enable intelligent software assistants for warfighters allowing them to delegate tasks such as information gathering, logistics supply, and operations planning that can be automated, but currently overload military personnel. Unlike other software, agents reduce the user's workload by operating autonomously and using available information to make intelligent decisions on behalf of the user. Agents are cost-effective; adaptive to new users, tasks, and computing environments; and collaborate with other agents on the network to solve problems. Agents also support a new lightweight approach for connecting dissimilar applications that don't speak the same language, but could be dramatically more powerful by sharing data and algorithms. Commercial industry is rapidly adopting intelligent agent technology because it potentially lowers software development costs and automates user tasks. However, being autonomous, agents can misinterpret user requests, go out of control, consume system resources, destroy user confidence, and eliminate any advantage to developers. Systems of agents produced by different developers can interact in complex ways. The Control of Agent-Based Systems Program will complement commercial investment by developing control strategies to ensure heterogeneous agent systems work correctly and predictably in the evolving Defense Information Infrastructure.

(U) Project Genoa is developing tools and a system for collaborative crisis understanding and management for the national security community from the National Command Authority to Commanders of the Unified Commands. The growing transnational threats increase the need for early crisis discovery and mitigation. The earlier a crisis situation is discovered, identified and understood at the National Command Authority level, the easier it is to arrive at preemptive or mitigating strategies. The objectives are to: (1) decrease decision cycle time from days to hours by reducing the time it takes to go from detection of a problem to completion of a thorough briefing with actionable options for the decision maker; (2) increase number of situations that can be managed simultaneously by an order of magnitude because with the increasing number of potential crisis situations and reduced resources we must make analysts more efficient, cover more situations and provide more diverse options; and (3) reduce number of military deployments. The key enabling technologies are: knowledge discovery of critical information from unstructured multimedia sources; structured argumentation to capture and present reasoning from evidence to conclusion; and a comprehensive corporate memory which will enable comparison of critical information across situation, time, and organization. The current clients for the prototype system are Commander in Chief Pacific (CINCPAC) and Director Defense Intelligence Agency (DIA). This project was initiated and budgeted in PE 0602702E, Tactical Technology, Project TT-03, but as it has evolved, it transitioned to CCC-01 in FY 1999.

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- (U) The Counter Trans National Threat (C-TNT) program will provide a means to reduce the threats of terrorism, weapons of mass destruction (WMD) proliferation, narcotics trafficking, information warfare, organized crime, and economic espionage. By leveraging current force protection and civil protection efforts and by exploiting promising technologies the C-TNT program will provide the framework for establishing an interactive global information system that will provide increased detection, understanding, warning and countermeasures effectiveness against these threats. The information system will utilize high bandwidth multi-national information exchange strategies and will exploit collaborative technology from such projects as GENOA and CPoF.
- (U) The purpose of the Commercial Awareness Initiative (CAI) program is to ensure that DoD can derive the maximum benefit of commercial research and development in information technology. This initiative will proceed in two phases. First, an analysis of near-term trends will be performed to determine the rate of maturation for existing and newly developed technologies. This analysis will help determine whether current and related DoD information technology programs are making effective use of commercially available technology. Second, long term projections will be made to map out anticipated developments and capabilities by commercial developers. The projections will be evaluated against DoD information technology needs and desired capabilities to identify specific areas for DoD technology development. The result will be the creation of an information technology investment strategy.
- (U) Program Accomplishments and Plans:
- (U) FY1998 Accomplishments:
- Demonstrated and evaluated the basic technology/application building blocks and system architecture for the JFACC Program (Phase 2). Initiated development of JFACC Phase 3 capabilities - an initial integrated campaign management and continuous planning and execution ability. Developed the combined benefit of operational systems analysis and campaign assessment. Developed and implemented control strategies and communication protocol standards for rapid integration of heterogeneous software applications. Identified interoperability requirements of several related ISO programs and the DI/GCCS. (\$ 30.377 Million)
  - Developed concept of operations for Integrated Battlespace Management Program. (\$ 2.954 Million)
  - Demonstrated Information Assurance (IA) automated capabilities to limit system access, and prevent system attacks by layering privacy security service over enclave-to-enclave protection and filtering out active code that is dangerous to enclave systems. Demonstrated gross



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responses for disabling attacks by shutting down outside connection and system-wide recovery. Demonstrated mechanism interoperability with negotiation protocols and good system administration tools to manage security mechanisms in DII LES. Integrated a basic Public Key Infrastructure certificate management system to support basic security services. (\$ 19.517 Million)

- Awarded AIM development contracts for initial Measures of Military Utility, trade studies and trade-off analysis, and designed tools for information management, strategy development, and multi-asset synchronization. Conducted a Concept Validation demonstration of emerging multi-asset synchronization algorithms. Conducted AIM Technology Symposium to demonstrate high-risk / high-payoff technology development areas for collection strategy optimization, predictive analysis for battlefield awareness, automated information needs development, and dynamic replanning for multi-asset synchronization. (\$ 7.638 Million)
- Completed the transition and provide one year of maintenance support to the operational Advanced Joint Planning ACTD to USACOM. Conducted a formal assessment of the ACTD's functionality. Completed transition of selected components to the current DII COE version via the AITS JPO. (\$ 1.813 Million)
- Developed standard low-cost method for integrating dissimilar software applications using translation. Identified interoperability requirements of several related DARPA programs. Developed generic control strategies limiting network resource utilization to maximum CPU utilization for a robust agent system. (\$ 2.920 Million)

(U) FY1999 Plans:

- Complete development, integrate and demonstrate, evaluate and initiate transition of JFACC Phase 3 capabilities to service battlelabs and the AITS JPO. Initiate development of JFACC Phase 4 capabilities - a robust, integrated campaign management and continuous planning and execution capability that achieves 70% of all responsiveness, resource efficiency, campaign effectiveness and process flexibility goals. (\$ 37.100 Million)

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- Demonstrate automated capabilities to limit system access, protect data, manage replication and recovery, provide advanced detection and response to intrusions, anti-flooding techniques, and reconstitute/reconfigure information services to reflect dynamic operational priorities. Demonstrate capability to do integrated monitoring of network service data, detected intrusion status and configuration/reconfiguration and to manage allocation of components and resources dynamically to reconstitute critical functions that have been degraded. (\$ 20.000 Million)
- Develop AIM tools for information management, strategy development, and multi-asset synchronization. Conduct data collections at Ulchi Focus Lens joint exercise to support technology development. Demonstrate integrated ISR and operations planning for the Information Superiority Demonstration 99. (\$ 10.000 Million)
- Develop and test cooperative, federated, and market-based control strategies for Agent-Based Systems to assist information gathering and enhance military planning capabilities. (\$ 14.100 Million)
- Project GENOA which is being transitioned from Tactical Technology, Project TT-03 this year, will install a test and evaluation site at CINCPAC as well as provide candidate technologies to DIA for possible inclusion in their intelligence projects. The test site will include initial knowledge discovery, structured argumentation, and argument presentation tools. (\$ 7.500 Million)

(U)

**FY2000 Plans:**

- Demonstrate, evaluate and initiate transition of selected capabilities of the JFACC System to operational users. Develop final Campaign Management functional capability to include: demonstration of integrated strategy development, objective/systems analysis and campaign assessment capabilities in an MRC scenario. Develop final Continuous Planning and Execution functional capability to include: generation of a comprehensive campaign plan for an MRC scenario in hours and continuous dynamic execution management. (\$ 24.437 Million)
- Demonstrate automated capabilities that enable dynamic, secure collaboration between enclaves including data and invocation flow rules. Demonstrate real-time, finer-grained advanced attack detection and response at the application layer, operating system, and network infrastructure. Couple advanced attack detection capabilities with automated system security and administration tools to enhance integrated monitoring and control of network services, detected attack status, and system configuration. Dynamically and automatically

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manage allocation of components and resources to reconstitute critical functions that have been degraded. Demonstrate security policy interoperability between enclaves. Explore Knowledge Base approach to adaptive systems management. Improve assurance measurement and risk analysis by establishing value functions for user data. Enhance object assurance granularity by augmenting Common Object Request Broker Architecture Security (CORBASEC). (\$ 29.000 Million)

- Demonstrate dynamic replanning capabilities within an integrated collection management demonstration. Develop collection, exploitation, and dissemination synchronization techniques to link all phases of ISR management in support of the warfighter. Transition initial automated collection strategy tools to the Integrated Collection Management efforts in the Defense Intelligence Agency and the Joint Staff. (\$ 10.000 Million)
- Develop an enhanced agent communication language, an agent programming methodology and component libraries. Identify standard, protective agent services. Integrate compatible models of agent behavior. Demonstrate and stress-test in a military exercise 5-fold speed-up to plan and execute a time-critical operation. For commanders critical information items, demonstrate automated tracking and notification with 95% reliability with less than 5% false alarm rate. (\$ 16.200 Million)
- In Project Genoa under knowledge discovery develop and implement information extraction from text and extensive use of intelligent agents, in structured argumentation refine crisis models and develop collaborative option generation, continue work on meeting transcription and develop ability to navigate and play back corporate memory. Implement products from Information Assurance project so that a multi-intranet system may operate at mixed security levels. Continue evaluation at CINCPAC test site. (\$ 12.000 Million)
- Counter Trans National Threat (C-TNT): Create preliminary information exchange architectures to allow integration of primary joint partners. Instantiate information fusion, assessment and alertment technologies from GENOA and CPoF. Perform a Concept Demonstration using currently available data streams. (\$ 8.809 Million)
- Commercial Awareness Initiative (CAI): Assess the state of integration of commercial information technologies into DARPA and related DoD programs. (\$ 5.000 Million)

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- (U) **FY2001 Plans:**
- Achieve comprehensive JFACC system integration and evaluation. Full functional capability of JFACC planning, execution and assessment system. Final transition to operational users. (\$ 24.734 Million)
  - Develop automated cyber immune response capability utilizing advanced attack detection indications and warning systems integrated with adaptive system monitoring and control. Apply artificial diversity to the adaptive systems. Develop security enabling technologies for autonomous software agents that allow agents to function safely across enclaves. Enhance object assurance granularity by augmenting DCOM and JAVA Remote Method Invocation (RMI). Develop automatic security policy discovery and negotiation capability among enclaves. Advance assurance measurement capabilities by developing IW attack countermeasure cost/benefit tools. Develop information warfare indications and warning (I&W) tools, utilizing data fusion techniques, to provide Defense Information Infrastructure (DII) wide I&W capability. (\$ 30.000 Million)
  - Conduct operational evaluation of AIM automated collection strategy development and multi-asset synchronization technologies. Incorporate predictive Indications and Warnings technologies into the automated collection strategy development tools. Transition multi-asset synchronization and automated collection strategy development tools to classified ISR management systems. (\$ 10.000 Million)
  - Scale-up reliable agent systems. Develop and test methods for understanding large-system autonomous behavior. Demonstrate proof-of-concept prototype for self-configuring software applications comprised of network services and quantify utility for highly complex, dynamic command and control problems. (\$ 12.800 Million)
  - Project Genoa: Incorporate changes resulting from client evaluation in real world environment. (\$ 7.000 Million)
  - Counter Trans National Threat (C-TNT): Incorporate select primary joint (multi-national) partner information systems into exchange architectures. Conduct the initial multi-national C-TNT demonstration. (\$ 10.000 Million)
  - Commercial Awareness Initiative (CAI): Project the far term commercial information technology areas and capabilities. Identify DoD-unique needs and create an investment strategy to address those needs. (\$ 10.000 Million)

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(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Oct 98	AIM Technology Symposium of automated information need generation and decomposition, multi-asset replanning capabilities, and initial developments for predictive capabilities for battlefield analysis.
Dec 98	Detect 80% of IW attack set, disable attacks by shutting down outside connection and system-wide recovery by system rollback to condition prior to attack.
Jun 99	Demonstrate computer network resource protection for pathogenic agent systems.
Sep 99	Demonstrate JFACC Phase 3 - integrated campaign management and continuous planning and execution capability.
Sep 99	Integrate a basic Public Key Infrastructure certificate management system to support basic security services. Demonstrate basic replication techniques and anti-flooding techniques (port filtering).
Sep 99	Demonstrate integrated ISR and operations planning at Information Superiority Demonstration (ISD) 99.
Jun 00	Demonstrate collaboration in multi-agent systems developed without hard-coded interfaces.
Jun 00	Demonstrate AIM automated collection strategy development and continuous multi-asset planning within an integrated collection management demonstration.
Jul 00	Demonstrate modular combined arms execution toolkit and small unit synchronizing toolkit.
Jul 00	Demonstrate Knowledge Base approach to systems management.
Jul 00	Demonstrate user data value functions.
Jul 00	Demonstrate rapid knowledge discovery and structured argumentation in crisis management.
Sep 00	Demonstrate augmented CORBASEC.
Sep 00	Demonstrate secure enclave-to-enclave collaboration. Demonstrate advanced intrusion detection and response capability integrated with dynamic system monitoring, control, and restoration.
Sep 00	Demonstrate and evaluate a robust integrated JFACC campaign management and continuous planning and execution system that demonstrates accomplishment of 70% of all responsiveness, resource efficiency, campaign and process flexibility goals.
Dec 00	Demonstrate tools for analysis of IW attack costs.
Dec 00	Demonstrate system recognition of malicious code.
Mar 01	CAI near-term technology implementation assessment.

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Mar 01

Demonstrate dynamic policy adjustment.

Jun 01

Demonstrate agents that dynamically create software interfaces; define scalability limitations.

Jul 01

Demonstrate CINC to tactical level integrated combined arms execution command and control with small unit synchronizing toolkit.

Jul 01

Demonstrate operational prototype crisis management system functionality.

Sep 01

Demonstrate prototype adaptive security system and prototype DII I&W system.

Sep 01

Demonstrate a full functional capability JFACC planning, execution and assessment system which meets all goals.

Sep 01

Conduct operational evaluation of AIM's automated collection strategy development and dynamic multi-asset synchronization tools. Initial demonstration of AIM's predictive indications and warnings technologies.

Sep 01

Demonstrate augmented DCOM and JAVA RMI.

May 02

CAI long-term technology development road map and investment strategy.

Jun 02

Demonstrate agent-based software technology for creating "super-applications" at run time.

Jul 02

Complete Project Genoa by turning over transition to customers.

Aug 02

Operational evaluation of integrated AIM capabilities for dynamic and proactive information needs generation, optimized collection strategy development, multi-asset synchronization for execution of the selected collection strategy, and continuous collaboration between operations and ISR.

Sep 02

C-TNT initial multi-national demonstration.

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BA3 Advanced Technology Development					PE 0603760E, Project CCC-02					
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Information Integration Systems CCC-02	82,306	111,400	123,640	108,544	117,849	110,549	118,549	117,549	Continuing	Continuing

(U) Mission Description:

(U) The goals of the Information Integration Systems project are to take diverse inputs, including those planned as outputs from the PE 0603762E Sensors and Exploitation Systems project (SGT-04), and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base, and through the use of wideband dissemination and integrated sensor management allow multi-site, real-time, collaborative situation assessment and course-of-action evaluations. These goals are being addressed by the Dynamic Multi-User Information Fusion (DMIF) program, the Dynamic Database (DDB) program, the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD), the Airborne Communications Node (ACN) program, the Command Post of the Future (CPoF) program, and Course of Action Analysis program.

(U) The Dynamic Multi-User Information Fusion (DMIF) program is the premiere fusion advanced technology development program for the defense and intelligence communities, including next-generation automated capabilities to support the operational service fusion systems: All Source Analysis System (ASAS), Theater Battle Management Core System (TBMCS), and Global Command and Control System (GCCS). The DMIF-created situation picture will reduce information overload and overcome barriers to interoperability among sensor exploitation sites, intel processing sites, and operators' decision nodes. DMIF will strategically control the multiple fusion resources found at such sites in order to create real-time mission focused pictures of the battlespace (related to the Common Operational Picture). The program is developing and inserting a product line of fusion capabilities that combine information directly obtained from multiple sensor-based sources (e.g., Human Intelligence reports and NRTI Signal Intelligence (SIGINT) information) as well as outputs from multiple fusion engines (such as those resident within TBMCS, ASAS, the Common Ground Station (CGS), or Regional SIGINT Operations Centers (RSOCs)). Any given insertion of DMIF would combine, focus, and rectify information from these disparate sources to provide the joint warfighter with a clear and actionable picture of the battlespace. In all these efforts, a key DMIF program objective and measure of success is focused, rapid and effective transition of advanced fusion technology to warfighters via technology transition efforts already underway with GCCS, ASAS, and the DARPA-DISA Joint Program Office.

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(U) The overarching goal of the Dynamic Database (DDB) program is to continuously produce significant battlespace information from immense quantities of multi-sensor data in a manner responsive to a diverse user community. More specifically, the DDB program will design, build, and demonstrate a system that (1) provides ready access to all battlespace sensor observations collected over time, (2) uses the resulting sensor history to identify and focus users' attention on tactically significant battlespace events, and (3) shares and synchronizes local situation changes across the distributed battlespace. Dynamic Database contents will be maintained and shared through a Dynamic Situation Model (DSM) that integrates geo-registered sensor history data with terrain, environmental, and force information to yield a logically consistent, multi-level view of the battlespace. Single and multi-sensor data fusion approaches will be developed that efficiently update the DSM by filtering tactically significant changes from the Dynamic Database sensor history. This objective includes the development of theory and techniques for incorporating mission and situation context into low-level processing algorithms, and advanced phenomenology models for translating expected conditions and behaviors into multi-sensor observables. Significant situation changes will be shared throughout the battlespace within a scalable "DDB enterprise" of distributed DSM nodes, computing applications, processors, and information repositories. DDB enterprise technologies will be developed to monitor database conditions for change, trigger external processes when conditions meet posted criteria, propagate changes across DSM nodes, and support queries and searches of distributed databases.

(U) The objective of the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD) is to deliver, install and evaluate an operational prototype system that delivers to warfighters a consistent operational picture of the joint/coalition battlefield, allows commanders to design/tailor their own information environment, and provides access to key transmission mechanisms and worldwide data repositories. The description of the battlespace provided to the warfighters under this ACTD will be tailored to their mission needs by intelligent selection of information to be broadcast, intelligent processing of user requests (pull) and filtering at the warfighter workstation so that needed information is available. BADD will be evaluated through participation in exercises and demonstrations, and by insertion into ongoing pilot services, such as the Joint Broadcast Service installed in the European Theater in April 1996. BADD is also operating under a Memorandum of Agreement with the Global Broadcast Service Program Office to provide advanced information management capabilities and new applications for this system as part of the overall transition plan of BADD developments to operations after test and evaluation in the ACTD. Selected applications and dissemination services will be transitioned to the Defense Information Systems Agency (DISA) for incorporation into the Defense Information Infrastructure Common Operating Environment (DII/COE).

(U) To avoid confusion, the Phase III (Technology Improvement) phase of BADD will henceforth be renamed to Agile Information Control Environment (AICE). AICE will focus on developing and demonstrating breakthrough information management technologies that provide 10 times improvement in the efficient and timely delivery of information; that extend current information management services to support time critical and real-time information flows (e.g., sensor to shooter); and that optimize information flows based upon maximizing the value of information delivered

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vs. today's practice of maximizing the volume of data delivered. To successfully demonstrate the operational payoff of these capabilities, AICE will develop a prototype MetaNet that provides end-to-end quality of service across multiple tactical and commercial-based networks. In addition, AICE will strive to develop a sound theoretical foundation for understanding information management systems and technologies.

(U) The Airborne Communications Node (ACN) program will provide a multifunction payload deployable on an airborne platform that demonstrates for the first time that a single communications node can interconnect more than 70 different channels and 17 waveforms, much beyond current radio range (beyond line of sight and horizon). This capability will provide tactical units with direct access to over-the-horizon communications capability and continuous broad area communications coverage over the battlefield, with cross-system connectivity amongst warfighters – on-the-move, Joint and Coalition forces - significantly improving rapid force projection, synchronization and synergy. To connect isolated and rapidly maneuvering forces via high data rate communications, provide reach-back connectivity to CONUS from forward elements, allow gateway connectivity among dissimilar radios and support secure channel-based dynamic configuration control requires the development of a system capable of providing reliable service in a severe EMI and jamming environment. This is achieved through the development of a highly flexible, software reprogrammable radio communication system that incorporates a complex cosite mitigation approach. A prototype payload is being developed to be supportable on a Global Hawk High Altitude Endurance unmanned airborne vehicle, but the system is designed to be flexible and scalable to any airborne platform for rapid deployment, including tactical UAVs and manned platforms, thus enhancing the existing legacy comms capability, providing new commercially-derived services (i.e., cellular) and enabling support for the small unit operations and mobile command centers of the future. The Airborne Communications Node program will integrate Warfighter Internet functionality to provide Internet-like communication services across multiple airborne nodes. The program will conclude with field demonstrations in FY 2002.

(U) The objective of the Command Post of the Future (CPoF) program is to improve the speed and quality of command decisions while reducing the number of staff members required to process and manage the information systems required to do so. The approach is to provide a very intuitive, well integrated, decision-centered, information environment in which the commander and a few staff members can quickly understand the changing battlefield situation, select the best course of action (COA), communicate that COA to the implementing units, and monitor the execution. The key technologies to be developed are: (1) an integrated visualization environment where the commander and his staff can view immediately understandable presentations of the changing battlefield situation, presentations which are tailored to the situation and the command decisions of interest; (2) a powerful and comprehensive human-computer interaction capability (through speech and gesture understanding, language understanding, dialog management, and visual collaboration) so that the commander and his staff can successfully understand and explore the information environment, without requiring dozens of staff members to operate and integrate multiple information systems; (3) a command post dialog manager which would automatically track current activities and tasks in the command post to tailor the information presentations to topics of interest; (4) an integrated suite of knowledge bases, intelligent agents, plan sentinels, information processing assistants which would automate many

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of the lower level staff functions and automatically invoke and operate supporting, planning and analysis applications; and (5) a modular, portable suite of hardware and software components that can be quickly configured and tailored to various command environments (stationary and mobile), at different echelons of command.

- (U) The Course of Action Analysis (COAA) program is focused on advanced technology development in the area of Course of Action Analysis. The program is developing a set of tools for performing COAA that can be demonstrated to determine the ability of these tools to support large-scale combat events.
- (U) The objective of the Integrated Demonstration project will be to show that multiple systems within this project and others can provide all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base, and through the use of wideband dissemination and integrated sensor management allow multi-site, real-time, collaborative situation assessment and course-of-action evaluations. Additionally, the Integrated Demonstration project will show how a combination of systems within this project and others that can provide access to all battlespace sensor observations collected over time, use the resulting sensor history to identify and focus users' attention on tactically significant battlespace events, and share and synchronize local situation changes across the distributed battlespace.
- (U) Program Accomplishments and Plans:
- (U) FY1998 Accomplishments:
  - DMIF: Continued development of the DMIF system to implement strategically controlled fusion, that is, real-time context-sensitive tasking of multiple fusion engines. This tasking adapts to the characteristics of available or incoming information, the performance of the available information processing applications (such as ASAS, CIS, or GCCS), and the specific tactical situation (as represented by the commander's critical intelligence requirements or via automated planning systems). By selecting fusion engines and tuning their parameters based on the real-time context, strategic control of multiple fusion engines ensures that users get peak performance over a much broader range of conditions than any single fusion engine could provide. Systems include fusion engines from the Army, Air Force, Navy, national agencies, and R&D systems. Demonstrated functionality at integrated operations/intelligence demonstrations with the JFACC program, the DARPA-DISA Joint Program Office, and transitioned components into ASAS. (\$ 11.689 Million)
  - Dynamic Database (DDB) Program: Completed the Phase I DDB architecture design. Installed the DDB System Integration Laboratory (SIL) to facilitate the exchange and evaluation of ideas and approaches, support distributed experimentation requirements, incubate and

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integrate evolving DDB technologies, and conduct system and technology proof-of-concept demonstrations. Laid the foundation for future DDB development by integrating existing "backbone" products (such as algorithms, phenomenology models, software, and databases) into the DDB SIL. In conjunction with DMIF, produced an initial object schema for the Dynamic Situation Model. Initiated single and multi-sensor fusion algorithms research and demonstrate a prototype update service for the sensor history layer of the Dynamic Database. Produced initial geo-registration and mosaicing tools for SAR, MTL, IR, and SIGINT sensor and incorporate tools in the Dynamic Database computation services. Developed a limited spatio-temporal database query capability. Produced an application programming interface specification for the Dynamic Database management system. Incorporated the initial Dynamic Situation Model object schema into the Dynamic Database and demonstrate the ability to ingest and process raw sensor data. Collected SAR, MTL, IR, EO, and SIGINT sensor data in preparation for FY 1999 activities. (\$ 14.986 Million)

- BADD ACTD: BADD is participating in and is being formally evaluated in an ACOM-conducted evaluation of the information dissemination management (IDM) programs first software release, increasing the level of automation previously provided to users and extending information management and dissemination support to the level of individual battalions/ships. BADD is providing new information management capabilities to include creation of a 3-D graphical depiction of a consistent operational picture by near-real-time integration of all relevant databases, and identification and semi-automated resolution of differences building on DMIF technology. BADD is also standing up the first digital tactical video server and demonstrating real-time population of that server, as well as automated meta-data generation for a number of tactical video surveillance platforms. BADD is creating a CONUS Pilot Service for ACOM components and demonstrating and delivering an OCONUS Pilot Service tailored for the Pacific theater supporting the IDM program at DISA and the GBS Joint Program Office. (\$ 43.820 Million)

- Airborne Communications Node (ACN): Selected multiple teams and initiated competitive ACN system design technology integration efforts. Initiated core technology integration from Warfighter's Internet and GLOMO programs and conducted initial technology investigations of very high bandwidth air-to-air and air-to-ground communications. The Warfighter's Internet Program integration with the ACN Program has begun. (\$ 8.318 Million)

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- Command Post of the Future: The program focused on defining operational concepts for the new system and developing a concept demonstration to show operational users for evaluation and feedback. A group of operational advisors was formed from service representatives at the Army Battle Command Battle Lab – Ft. Leavenworth, the Mounted Maneuver Battle Lab at Ft. Knox, and the Marine Corp Warfighting Lab at Quantico. User studies were conducted by visiting operational military units to construct initial concepts of operation for CPOF, focusing on the Joint Land Forces Component Commander (JFLCC) as the target user. A concept demonstration was developed by integrating emerging technology in visualization, speech understanding, human-computer interaction, and decision aids to create an initial demonstration of envisioned CPOF capabilities. The demonstration will be presented to operational users for valuation to further discuss and refine the operational concepts for CPOF. (\$ 3.493 Million)

(U) FY1999 Plans:

- Continue the development of DMIF functionality. Move from static to dynamic strategic fusion control in order to react, in real time, to new incoming observations or new information requirements from users. Move from pre-loaded to “agile” information models in order to incorporate, in battle-relevant timeframes, new knowledge about enemy forces and tactics. Add to the number of fusion engines (at least twelve systems) that are strategically controlled by DMIF, thereby both improving the performance of the confederated fusion engines and extending the interoperability of all systems, which are, associated with the encapsulated fusion engines. Integrate selected DMIF services into broader environments that require entity-level fusion, specifically the Dynamic Database, GCCS, ASAS, and AITS, to create a product line of fusion systems that work flexibly and seamlessly with existing and emerging battlefield information systems. Complete integration and lab demo of DMIF II and demonstrate multi-service ops-intel interoperability with ASAS & AFATDS at an XVIII Airborne Corps operational exercise. (\$ 8.000 Million)
- Complete a Phase II DDB architecture design that integrates DDB and DMIF technologies. Expand the Dynamic Situation Model object schema to include pedigrees that map entity-level situation assessments to multi-sensor source data. Develop and validate single-sensor terrain and entity phenomenology models. Develop prototype multi-sensor target phenomenology models. Elicit and incorporate situation context into single and multi-sensor anomaly detection algorithms. Demonstrate a prototype update service for the entity layer of the Dynamic Database. Extend database query services to include limited content-based index and query capabilities. Leverage existing COTS/GOTS technology to develop interactive tools for manipulating and visualizing Dynamic Database contents. Integrate technology products in the DDB SIL and demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns and mosaics the data within a common 2-D spatio-temporal reference frame, identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Dynamic Situation Model, and provides the user ready access to sensor history data. (\$ 30.000 Million)

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- BADD ACTD: Complete military utility assessment at Roving Sands. Begin the 2-year ACTD sustainment phase. Operate Pilot Services and begin transition of initial CONUS and OCONUS Pilot Services to DISA. Complete the transition of integrated tactical video services to NIMA (video archiving tools) and to DISA/GCCS (video viewers). (\$ 17.862 Million)
- AICE: Begin AICE technology development in MetaNet, Adaptive Information Control (AIC) and Information Policy Management (IPM) areas. Begin theoretical framework and metrics development. Begin developing prototype MetaNet consisting of tactical networks (MSE, CEC, LINK16), DISN networks, and commercial networks. Begin development of information flow optimization technologies for dynamic channel building and global, content-based information utility maximization. Generalize the concept of metadata attribute spaces stated in the BADD ACTD, and develop the multi-dimensional vectorspace-based algebra required to achieve other AICE technical goals. (\$20.438 Million)
- Airborne Communications Node (ACN): Continue the execution of the design phase with multiple system design teams and initiate payload design and development for a proof of concept - functional - demo in early FY 2000. Continue ACN technology integration and experimentation and conduct lab demonstrations to verify mitigation approaches/designs for high-risk areas such as EMI/cosite and antenna coupling/range. (\$ 23.500 Million)
- Command Post of the Future (CPoF): The program will begin to develop CPoF technology, an integration environment, and begin work to design a series of decision experiments to test the effectiveness of the CPoF system to improve command decisions. Technology development will begin to create a new suite of human-systems interaction technology, the major technology emphasis of the program, to include work in cognitive engineering, displays and workspace design, visualization, multi-modal user interaction, and dialog management and reasoning. System integration will also begin to refine and integrate the individual technologies into a complete CPoF system for testing in simulation-based Command Post exercises. Experiment planning will begin with user representatives from the service battle labs to define operationally meaningful test problems and design a series of simulation-based decision experiments to test the effectiveness of the new technology in improving command decisions. The first version of an integrated CPoF system will be created and tested at the end of FY 1999. (\$ 11.600 Million)

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(U) FY2000 Plans:

- BADD ACTD: Complete the 2-year ACTD sustainment phase. (\$ 7.570 Million)
- AICE: Complete the development of metadata vectorspace-based algebra and use it to develop dynamic and conditional information profiling capabilities. Continue development of advanced information management technologies including Large-Scale Dynamic Channel Building Algorithms, Global Quality-of-Service Optimization, and Information Management Services to moving entities. Demonstrate prototype MetaNet providing end-to-end quality-of service across tactical, DoD DISN, and commercial IP networks, as well as DoD tactical networks. Evaluate and select highest payoff technologies for insertion and evaluation within the BADD ACTD architecture. Begin investigation of incorporating ACN as part of the MetaNet. (\$ 23.870 Million)
- Support transition of core DMIF functionality, including real-time dynamic strategic control of at least 12 existing fusion engines, using a combination of classical control theory, fuzzy logic, and resource constraint optimization. Supply metrics for quantitative assessments of the value-added of strategically controlled information fusion, including reductions in total data elements presented to users, reductions in numbers of incorrect and out-of-date hypotheses and in location and identification errors. Performance comparisons will be made between a confederation of DMIF-controlled fusion engines and those same fusion engines operating stand-alone. All working DMIF code will be integrated into the Dynamic Database in order to enhance that program's early capabilities and to further develop advanced concepts initially explored under DMIF. More mature DMIF technology developed over the last five years will be transitioned to at least the DII COE and GCCS (DISA) and to ASAS (Army office of Program Management for Intelligence Fusion), providing Joint and Service capabilities for reducing information overload and improving interoperability for situation awareness. (\$ 1.000 Million)
- Complete a Phase III DDB architecture design that prototypes a single node DDB SIL. Expand the Dynamic Situation Model object schema to include pedigrees that automatically map entity-level situation assessments to multi-sensor source data using data-driven fusion methodologies. Extract and fuse enhanced multisensor data features over time. Include visible EO into the stored data-types. Develop and validate multiple-sensor terrain and entity phenomenology models. Validate prototype multi-sensor target phenomenology models. Incorporate automatic situation context into single and multi-sensor anomaly detection algorithms. Demonstrate an interactive prototype update service for the entity layer of the Dynamic Database. Extend database query services to include ad-hoc user requested content-based index and query capabilities. Leverage existing COTS/GOTS technology to update interactive tools for manipulating and visualizing Dynamic Database contents. Upgrade technology products in the DDB SIL and demonstrate an interactive prototype DDB

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system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common 3-D spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Dynamic Situation Model, and provides the user ready access to sensor history data and entity-level situation hypotheses. Incorporate DDB technology in XVIII Airborne Corps 525th Military Intelligence (MI) Brigade forward sensor enclave (FSE) testbed. (\$ 30.000 Million)

- Command Post of the Future (CPoF): The program will produce new technology components, which will enable commanders to double the speed and quality of command decisions. Technology will be produced to enable the commander and his staff to easily access information and quickly understand changing battlefield situations by speaking, pointing and naturally interacting with a suite of high-resolution displays in a CPoF environment. Technology will be produced to automatically generate visual presentations of battlefield information, tailored to the individual commander's background, preferences, current situation, task, and topic of interest. Different versions of these technology components will be integrated and tested in a series of simulation-based decision experiments. (\$ 18.000 Million)
- Airborne Communications Node (ACN): Conduct proof of concept manned aircraft demonstrations of competitive ACN system designs and down select to a single team for full function payload design and development. This design will be targeted to operate within the stringent environmental of the Global Hawk high altitude endurance unmanned aerial vehicle, thereby stressing the packaging technology required to meet the form, fit and function. This will enable subsets of the full functionality and design to be easily transferred to other SWAP-limited platforms like tactical UAVs. Complete final system designs and begin system integration. Conduct laboratory demonstrations of critical subsystems. (\$ 33.200 Million)
- Integrated Demo: Conduct an integrated demonstration of multiple systems within this project and others that will provide all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base, and through the use of wideband dissemination and integrated sensor management allow multi-site, real-time, collaborative situation assessment and course-of-action evaluations. (\$ 10.000 Million)

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(U) FY2001 Plans:

- AICE: Demonstrate the capability to support real-time information flows across the MetaNet. Develop mechanisms for visualizing and understanding the macro structure of information flows supporting a large military operation. Automate the generation of information management policies based upon commander's intent. Assess military utility. Transition into the DII COE via the BADD Phase II architecture. (\$ 25.144 Million)
- DDB: Complete Phase IV DDB architecture design prototype and demonstrate an interactive 2-node capability in the DDB SIL. Expand the Dynamic Situation Model object schema to include pedigrees that automatically map force-level situation assessments to multi-sensor source data using data-driven & model-driven fusion methodologies. Include video data into the stored data-types. Extract and fuse visible EO to extend multisensor data features over time. Develop and validate EO & video terrain and entity phenomenology models to incorporate streaming video into the mosaic display process. Incorporate automatic access to all levels of situation context into single and multi-sensor anomaly detection algorithms. Demonstrate a fully interactive prototype update service for the entity layer of the Dynamic Database. Extend database query services to include rapid access to all levels of situation information in response to pre-defined user profile requested content-based index and query capabilities. Continue to leverage existing COTS/GOTS technology to update interactive tools for manipulating and visualizing Dynamic Database contents. Continue to upgrade technology products in the DDB SIL and demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common 3-D spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Dynamic Situation Model, and provides the user ready access to sensor history data, entity- and force-level situation hypotheses. Incrementally update intelligent DDB services in 525th MI FSE testbed. (\$ 30.000 Million)
- Command Post of the Future (CPoF): The program will continue to develop and integrate new CPoF technology into a complete CPoF system to enable commanders to double the speed and quality of command decisions. New versions of the technology components developed in FY 1999 will be integrated and tested in a series of simulation-based decision experiments. The most effective technology will be integrated into a complete CPOF system for an end-to-end demonstration of in a simulated joint exercise. Preparations will begin for an operational demonstration of the CPoF system in a joint field exercise in FY 2002. (\$ 22.000 Million)

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- Continue to develop COAA technologies and extend and integrate its capabilities with the JFACC program. The initial COAA development was funded under PE 0603761E, Project CST-01. (\$ 6.000 Million)
- Airborne Communications Node (ACN): Complete full system integration, extend laboratory demonstrations across multiple subsystem components, plan extensive ground interaction and flight demonstrations with joint warfighters, and conduct multi-platform (including Global Hawk) flight demonstrations in Joint Warfighter environments. (\$ 11.400 Million)
- Integrated Demo: Conduct an integrated demonstration of a combination of systems within this project and others that will provide access to all battlespace sensor observations collected over time, use the resulting sensor history to identify and focus users' attention on tactically significant battlespace events, and that will share and synchronize local situation changes across the distributed battlespace. (\$ 14.000 Million)

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(U)	<u>Other Program Funding Summary Cost:</u>		Not Applicable.
(U)	<u>Schedule Profile:</u>		
	<u>Plan</u>	<u>Milestones</u>	
	Sep 98	Complete prototype design of the Command Post of the Future.	
	Sep 98	DMIF demonstration of focused situation awareness in joint-level simulation with JFACC, service and Agency migration systems (ASAS, DII COE).	
	Oct 98	DDB Phase I design complete; DDB SIL installation complete; specification for sensory history database complete.	
	Oct 98	Complete Military Utility Assessment of BADD Release 1.	
	Nov 98	Deliver BADD information management and battlefield awareness products for IDM EOC3.	
	Mar 99	Complete Military Utility Assessment of BADD Release 2.	
	Jun 99	Complete BADD ACTD Military Utility Assessment at Roving Sands.	
	Jun 99	Demonstrate single node prototype DDB technologies, to include sensor history database and computation services (registration and mosaicing) for SAR, IR, SIGINT, and MTI.	
	Sep 99	Test integrated Command Post of the Future system.	
	Oct 99	AICE assessment environment operational.	
	Nov 99	Complete AICE Release 1.	
	Dec 99	Complete initial ACN System Design Reviews and conduct proof of concept flight demonstrations.	
	Dec 99	Demonstrate an interactive DDB multi-sensor history database and entity-level situation assessment service (extending the services to include EO).	
	Jan 00	Downselect to one ACN Team.	
	Mar 00	Participate in major field test experiment (Ulchi Focus Lens) operating on live and simulated data from multiple sensors.	
	Apr 00	Complete AICE theoretical framework.	
	Jul 00	Demonstrate Smart Adversary to Army.	
	Aug 00	Complete DMIF transition to DISA, the Services, and DDB program.	
	Sep 00	Complete BADD ACTD transition to DISA, GBS Joint Program Office (JPO) and the Services.	
	Sep 00	Demonstrate AICE prototype MetaNet.	
	Oct 00	Phase III complete. Incorporate DDB technology into XVIII Airborne Corps 525th MI Brigade FSE Testbed.	
	Nov 00	Complete AICE Release 2 technology products.	
	Dec 00	Demonstrate an interactive DDB system that ingests raw multi-sensor data, aligns, mosaics and displays the data within a 3-D Spatio-temporal reference frame in the SIL.	
	Jun 01	Demonstrate a fully interactive dual-node DDB entity- and force-level situation assessment service (extending the services to include video).	
	Jul 01	Demonstration of Smart Adversary extended to Navy and Air Force.	

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Aug 01  
Sep 01  
Sep 01  
Sep 01  
Oct 01  
  
Mar 02  
Aug 02  
Sep 02

Complete ACN Payload Integration, laboratory and antenna range tests.  
Demonstrate COAA level analysis within major Army exercises (e.g., Advanced Warfighter Experiment -AWE).  
Demonstrate real-time flow support, AICE MetaNet.  
Complete AICE technology transition into the DII COE via the BADD Phase II architecture.  
Phase IV complete. Incrementally update DDB technology into XVIII Airborne Corps 525th MI Brigade FSE Testbed.  
Begin preparation to expand DDB into a multi-sensor, multi-node-distributed architecture.  
Complete ACN payload integration and test with Global Hawk.  
Complete ACN field demonstrations.  
Complete ACN transition.

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PE 0603761E										
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	70,165	56,114	5,250	0	0	0	0	0	0	N/A
Advanced Simulation CST-01	29,050	26,698	0	0	0	0	0	0	0	N/A
Global Grid Communications CST-02	38,519	27,916	5,250	0	0	0	0	0	0	N/A
Defense Simulation Internet (DSI) CST-03	2,596	1,500	0	0	0	0	0	0	0	N/A

(U) Mission Description

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because it's purpose is to demonstrate and evaluate advanced simulation technologies and networking systems that will seamlessly integrate command and control functions needed for future global defense operations.

(U) The Advanced Simulation project is developing advanced simulation technologies that provide seamless synthetic battlespace that will enable high fidelity simulation across a full range of DoD functions. As technologies mature, they are integrated, tested and demonstrated in exercise/demonstrations of varying size and complexity. Within this project, the Synthetic Theater of War (STOW) Advanced Concept Technology Demonstration (ACTD) program is developing advanced simulation technologies to provide a seamless synthetic battlespace to support joint training and mission rehearsal activities. These technologies will be transitional to service and joint simulation developers at the end of FY 1999.

(U) The Global Grid Communications project is developing and demonstrating advanced networking technologies needed for global defense operations in the 21st century. Network services will be developed in order to support geographically dispersed staff for crisis management and to support warfighters in rapid deployment, highly mobile scenarios. The program requires the design, adaptation and development of new internetwork protocols. The three main efforts in this project are: (1) the Joint Task Force Advanced Technology Demonstration (JTF-ATD) of a rapid Commander Joint Task Force (CJTF) crisis response capability for a range of situations from multiple regional conflicts (MRCs) to operations other than war (OOTW) capable of being established and operational in days; (2) the Warfighter's Internet program which will develop and

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demonstrate a mobile wireless backbone communications network consisting of multiple airborne nodes which in turn connect to users and networks on the ground, on the ocean, and in the air, and (3) the Broadband Information Technology (BIT) program which seeks to develop all-optical multiple wavelength transmission and networking technologies.

(U) The goal of the Defense Simulation Internet (DSI) program is to research, develop and test at scale (worldwide), a network infrastructure capable of enabling distributed, real-time, multi-media (video, voice, shared data and work spaces) simulation that will seamlessly integrate all simulation, modeling, command and control functions from early design to battle rehearsal enroute to the conflict. The DSI transitions to the Defense Information Systems Agency (DISA) Defense Information System Network (DISN) on a fully reimbursable basis at the end of FY 1999.

(U)	<b><u>Program Change Summary: (In Millions)</u></b>	<b><u>FY1998</u></b>	<b><u>FY 1999</u></b>	<b><u>FY 2000</u></b>	<b><u>FY 2001</u></b>
	Previous President's Budget	74.212	56.114	29.750	31.049
	Current Budget	70.165	56.114	5.250	0.000

(U) **Change Summary Explanation:**

FY 1998 Decrease reflects rephasing of Warfighter's Internet and SBIR reprogramming adjustments.  
 FY 2000-01 Decreases reflect transition of Defense Information Infrastructure Common Operating Environment (DII COE) to AITS JPO, and completion of the Broadband Information Technology and Warfighter's Internet programs.

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COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Advanced Simulation CST-01	29,050	26,698	0	0	0	0	0	0	0	N/A

(U) Mission Description:

(U) The strategic environment in which the United States operates will require Joint Forces to operate across the full spectrum of conflict. At the same time, resources will continue to shrink, requiring the Department to search for the most cost effective means to perform the full spectrum of defense functions. To support the National Military Strategy, the Advanced Distributed Simulation (ADS) program is developing advanced simulation technologies that provide seamless synthetic battlespace that will enable high fidelity simulation for Joint/Service readiness training and mission rehearsal. As technologies mature, they are integrated, tested and demonstrated in exercises/demonstrations of varying size and complexity. Within the ADS Programs the Synthetic Theater of War (STOW) Advanced Concept Technology Demonstration (ACTD) program is developing advanced simulation technologies that provide a seamless synthetic battlespace to support joint training and mission rehearsal activities. STOW applied high fidelity, platform level simulation technologies across the full spectrum of conflict enabling evolutionary changes in how joint forces train and rehearse for operational missions. The ultimate goal is to develop mature simulation technologies capable of representing Joint Forces from the level of Operations Other Than War (OOTW) up to the Joint Task Force level of combat. Specific technology efforts being undertaken as part of STOW include: 1) Multiple simulation system interfaces to real world C4I systems; 2) Advanced Distributed Networking; 3) Initiation of DoD's High Level Architecture (HLA) within the simulation; 4) Advanced synthetic forces and environmental databases; and 5) Interoperability with the United Kingdom Synthetic Environment Program. These technologies will be transitioned to Service and joint simulation developers at the end of FY 1999.

(U) The STOW prototype has supported the United States Atlantic Command (USACOM) JTF level exercise, Unified Endeavor 98-1 in October 1997, and will support subsequent USACOM exercises during FY 1998 and FY 1999. Operational experience in these entity based simulation events provides valuable lessons learned, documentation, software products and tools/applications to support DoD's emerging family of Joint Simulation Systems, e.g. JSIMS, WARSIM, NASM, JSIMS Maritime component.

(U) The existing Operational Simulation (OPSIM) Technology Program has been divided into two programs. The Advanced Simulation Technology Thrust (ASTT) builds on the STOW Program and develops advanced simulation technology supporting the next generation of DoD simulation systems. The goal of the ASTT program is to solve core simulation technology issues such as advanced synthetic environments modeling, multi-resolution modeling, and scaling. The ASTT program acts as a technology bridge to future DoD simulation developments such as

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the Joint Simulation System (JSIMS). The other element of the OPSIM program called Course of Action Analysis integrates Advanced Distributed simulation and ASTT developed technologies into operational planning systems to provide course of action analysis for operational users.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Based on lessons learned from Unified Endeavor 98-1 and USACOM revised operational requirements, improved the STOW prototype and provided operational demonstrations of an increased capability to the joint warfighter in support of USACOM and the services. This included enhancing the warfighter's capabilities to employ high fidelity, platform level simulations for a variety of missions, by improving technology, tools and applications. Integrated new/improved synthetic environments, synthetic forces, and networking technologies as well as products developed in conjunction with the United Kingdom's Synthetic Environment Program. Continued transition of STOW technologies to JSIMS and other DoD users. (\$ 12.619 Million)
- Continued development of Advanced Simulation Technologies in the ASTT program to support JSIMS, WARSIM and other service simulations. Technology efforts included: Adaptive multi-skilled Synthetic Forces; scalability to greater than 20,000 objects; distributed multi-cast data collection on large amounts of data; rapid generation of computer generated forces and alternative methods of Synthetic Force generation; single synthetic environments database abstraction to accommodate multiple simulation requirements; initial multi-resolution modeling techniques. (\$ 11.521 Million)
- Continued to develop and demonstrate Course of Action Analysis (COAA) technology based on advanced simulation technology and related modeling techniques. Extended FY 1997 effort to provide a tightly coupled COA development/COA analysis environment that shortens the overall planning cycle by 50%. Evaluated: extension of COAA technology to other Services; next generation COAA analysis techniques (such as advanced adversarial reasoning); and the techniques necessary to tightly integrate the mission planning/mission rehearsal/mission execution monitoring end-to-end process as it applies to land combat. (\$ 4.910 Million)



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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-I ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E, Project CST-01	

(U)

Program Accomplishments and Plans:

(U)

FY1998 Accomplishments:

- Based on lessons learned from Unified Endeavor 98-1 and USACOM revised operational requirements, improved the STOW prototype and provided operational demonstrations of an increased capability to the joint warfighter in support of USACOM and the services. This included enhancing the warfighter's capabilities to employ high fidelity, platform level simulations for a variety of missions, by improving technology, tools and applications. Integrated new/improved synthetic environments, synthetic forces, and networking technologies as well as products developed in conjunction with the United Kingdom's Synthetic Environment Program. Continued transition of STOW technologies to JSIMS and other DoD users. (\$ 12.619 Million)
- Continued development of Advanced Simulation Technologies in the ASTT program to support JSIMS, WARSIM and other service simulations. Technology efforts included: Adaptive multi-skilled Synthetic Forces; scalability to greater than 20,000 objects; distributed multi-cast data collection on large amounts of data; rapid generation of computer generated forces and alternative methods of Synthetic Force generation; single synthetic environments database abstraction to accommodate multiple simulation requirements; initial multi-resolution modeling techniques. (\$ 11.521 Million)
- Continued to develop and demonstrate Course of Action Analysis (COAA) technology based on advanced simulation technology and related modeling techniques. Extended FY 1997 effort to provide a tightly coupled COA development/COA analysis environment that shortens the overall planning cycle by 50%. Evaluated: extension of COAA technology to other Services; next generation COAA analysis techniques (such as advanced adversarial reasoning); and the techniques necessary to tightly integrate the mission planning/mission rehearsal/mission execution monitoring end-to-end process as it applies to land combat. (\$ 4.910 Million)

(U)

FY1999 Plans:

- Continue to refine and demonstrate prototype technologies in support of USACOM and the services. Demonstrations will focus on the representation of a seamless land/sea/air warfighting synthetic environment with an ever-increasing degree of realism, and C2 interfaces,

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to support Service and joint operational training and analyses while retaining the arbitration of battle outcomes at the platform level of resolution. Transition of technology, tools and applications will continue in support of the next generation of DoD simulations. (\$ 13.798 Million)

- Continue to develop high risk Advanced Simulation Technologies required by, and in coordination with, JSIMS and other Service simulations (e.g. WARSIM) to meet their respective Full Operational Capability (FOC) requirements. Technology efforts will include: demonstrating advanced time management and filtering techniques required to support JTF level exercise; reducing the cost of generating realistic behaviors capable of goal-based reasoning for synthetic command entities; demonstrating advanced techniques capable of creating and maintaining a consistent environment that supports correlated operation of force-on-force simulation at multiple levels of resolution. Continue to transition all technologies to JSIMS, et al. (\$ 12.900 Million)

(U) FY2000 Plans: Not Applicable.

(U) FY2001 Plans: Not Applicable.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Sep 98	Demonstrate ability for ADS network to support real-time transport of a .3 Gigabyte at 3k transactions per second.
Sep 99	Complete the development, integration and documentation of the STOW prototype. Complete final transition of STOW Technology to JSIMS/WARSIM/NASM/JSIMS MARITIME.
Sep 99	Transition ASTT simulation technologies to the JSIMS and the Service simulation developments.
Sep 99	Program completion and close out.

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RDT&E, Defense-wide				Communication and Simulation Technology							
BA3 Advanced Technology Development				PE 0603761E, Project CST-02							
COST (In Thousands)		FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Global Grid Communications CST-02		38,519	27,916	5,250	0	0	0	0	0	0	N/A

(U) Mission Description:

(U) This project develops and demonstrates advanced networking technologies needed for global defense operations in the 21st century. Network services will be developed in order to support geographically dispersed staff for crisis management and to support warfighters in rapid deployment, highly mobile scenarios. The program will demonstrate that information technologies can be integrated with both advanced optical, high performance networks and mobile, wireless tactical. This will provide multimedia information flows, efficient use of bandwidth, and minimal logistical requirements for warfighting, disaster relief, emergency medical support. The program requires the design, adaptation and development of new internetwork protocols.

(U) The goals of the Joint Task Force Advanced Technology Demonstration (JTF ATD) include development of a rapid Commander Joint Task Force (CJTF) crisis response capability for a range of situations from multiple regional conflicts (MRCs) to operations other than war (OOTW) capable of being established and operational in days; provide collaborative planning tools to enable the development of integrated, executable operations plans in hours; provide en route planning and execution management for the JTF staff; provide a software reference architecture that provides access to the defense information infrastructure (DII), links the national command authority (NCA), commander in chief (CINC), JTF and the components, and enables rapid tailoring of the operational environment; provide common servers and application suites; and finally, to migrate the capability to the DII by the end of FY 1999.

(U) The goal of a Warfighter's Internet is to expand open architecture and internetworking technologies into the mobile wireless domain to provide a robust, automatically reconfigurable, internetworking capability; and, to support warfighters in rapid deployment and highly mobile scenarios. This will be accomplished as a joint effort with the Airborne Communications Node program and will enable a backbone communications network consisting of multiple airborne nodes which in turn connect to users and networks on the ground, on the ocean, and in the air. Provision for multimedia information flows, efficient use of bandwidth, and minimal logistical requirements are key objectives that require the design, adaptation and development of new network protocols for mobile, wireless battlefield networks. Technology development and demonstration will focus on networking technologies to integrate existing and developmental communication systems and networks using airborne

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nodes such as Global Hawk (Airborne Communications Node). A scalable internet will be demonstrated in conjunction with joint service exercises and advanced warfighting experiments.

(U) The Broadband Information Technology (BIT) program seeks to develop all-optical multiple wavelength transmission and networking technologies. Specifically, this program has four goals: (1) a billion bit per second bandwidth on demand, independent of the analog and digital nature of the applications, (2) rapid, nearly transparent reconfiguration of network routing, (3) multiplexing of continuous transmission rates (bit rates from thousands of bit per second to billion of bits per second), and (4) transmission of analog and digital signals in a single fiber.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- The Broadband Information Technology project demonstrated multi-wavelength network management and control in local area testbeds. (\$ 6.195 Million)
- Broadband Information Technology project demonstrated 40 billion bits per second cross-connect switching and 32 channel transceiver chip. (\$ 8.700 Million)
- Continued analysis and report on economics of multi-wavelength network architecture and technology for local area optical networks. (\$ 1.300 Million)
- Continued integration with advanced information technology services needed to extend the Joint Task Force (JTF) Infrastructure by providing "composable Advanced Information Technology (AIT) services" that supported the planning phase, the execution phase, and the dynamic replanning phase. Developed Java-compatible Object Web Tools for generic plan editing, and demonstrated persistent brief development tools, bandwidth adaptive object based distribution and sharing, and schema unified semantic interoperability of several applications. Supported the extension of the infrastructure, architecture, servers and applications across computing platform classes and to emerging and related programs within the DARPA C2 development environment with the "composable AIT services". Transitioned additional components to the current Defense Information Infrastructure Common Operating Environment version via the AITS JPO. (\$ 16.599 Million)
- Completed design and development of first phase of mobile, wireless network software and protocols, self-organizing cross links, network and mobility management, security, application interfaces, signalling protocols and RF subsystem integration and engineering based on the DARPA-led, joint Service study that defined technical requirements and network systems architecture for a Warfighter's Internet/joint

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tactical internetwork. Integrated technology with the Airborne Communications Node payload requirements/design. Continued Advanced Digital Receiver and radio frequency microelectromechanical systems (RF MEMS) Tunable Filters technology efforts. Initiated time varying magnetic flux antenna investigation. (\$ 5.725 Million)

(U) **FY1999 Plans:**

- Broadband Information Technology project will demonstrate full operations, multi-wavelength, experimental, system network including interoperability among testbeds distributed across several geographic domains. (\$ 6.049 Million)
- Develop software applications and servers from the "composable AIT services", and expand the JTF reference architecture to include execution and dynamic replanning. Transition selected "composable AIT services" to the AITS JPO for future incorporation into the DII COE. Demonstrate rapid development of specialized plan viewers for multiple echelons. Develop distributed information logistics services for optimization of time-value of information delivery. Support the extension of the infrastructure, architecture, servers and applications across computing platform classes and to emerging and related programs within the DARPA C2 development environment using the "composable AIT services" model. Transition additional components to the current DII COE version via the AITS JPO. (\$ 6.000 Million)
- Warfighter's Internet project will integrate technology with the Airborne Communications Node developments. In coordination with Airborne Communications Node, initiate test & demonstration of airborne cross links, wireless backbone using manned aircraft; continue to develop network protocols and integrate into commercial products; integrate legacy and emerging radios in mobile, wireless internet. Demonstrate increased warfighter capabilities as part of combined ACN demonstration in early FY 2000. Complete Advanced Digital Receiver technology development and integration. Continue RF MEMS Tunable Filter, programmable INFOSEC, advanced digital transmitter/external power amplifier and antenna technology developments. (\$ 15.867 Million)

(U) **FY2000 Plans:**

- Broadband Information Technology project will demonstrate ferroelectric liquid crystal switching at microsecond speed. (\$ 5.250 Million)

(U) **FY2001 Plans:** Not Applicable.

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(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
1Q FY99	Conduct laboratory proof of concept demonstration of Warfighter's Internet hardware and software.
3Q FY99	Demonstrate 20 gigabit per second, multi-channel, multi-media, large-area network.
4Q FY99	Demonstrate advanced execution and dynamic replanning functionality and transition selected "composable AIT services" to AITS JPO.
4Q FY99	Field demonstration of mobile wireless network technologies coordinated with BADD, Extended Littoral Battlespace (ELB) and Small Unit Operations experiments.
4Q FY99	Complete Advanced Digital Receiver and RF MEMS Tunable Filters upgrades.
4Q FY00	Demonstrate ferroelectric liquid crystal optical switching.

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RDT&E, Defense-wide				Communication and Simulation Technology							
BA3 Advanced Technology Development				PE 0603761E, Project CST-03							
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Defense Simulation Internet (DSI) CST-03	2,596	1,500	0	0	0	0	0	0	0	N/A	

(U) Mission Description:

(U) The goal of the Defense Simulation Internet (DSI) program is to research, develop and test at scale (worldwide), a network infrastructure capable of enabling distributed, real-time, multi-media (video, voice, shared data and work spaces) simulation that will seamlessly integrate all simulation, modeling, command and control functions from early design to battle rehearsal enroute to the conflict. The DSI meets DoD security requirements by using a commercial-off-the-shelf (COTS) encryption device (INES). The communications needs of the distributed, real-time, multi-media modeling and simulation community cannot be met with any other available technology. Commercial vendors are pursuing some of the required technologies, but development is too slow and unfocused to accommodate the immediacy of the Department of Defense's simulation requirements. The DSI program provides focus for the commercial development of the technologies needed by the simulation community for distributed work environments worldwide. Over 100 nodes currently extend the DSI to each of the Services, most of the Commanders-in-Chief (CINCs), some of our allies and other Government affiliated sites. These locations constitute the network's user sites; they provide valuable feedback on the technologies and methodologies being pursued and critical capability for both ongoing and major modeling and simulation events. DSI provided real time infrastructure for the Synthetic Theater of War (STOW) 97.

(U) The DSI will complete the transition to the Defense Information Systems Agency (DISA) Defense Information Systems Network (DISN) to be operational on a fully reimbursable basis by the end of FY 1999. Between FY 1998 and FY 1999, it will be jointly managed by DISA and DARPA through the Advanced Information Technology Systems Joint Program Office. The transition of the DSI into the DISN provides affordability through consolidation of the costs required to operate multiple networks while continuing to support modeling and simulation requirements.

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(U)

Program Accomplishments and Plans:

(U)

FY1998 Accomplishments:

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Transition management: Provided programmatic integration management and engineering support through the DARPA/DISA Advanced Information Technology Systems (AITS) Joint Program Office (ADIPO) to identify and evaluate advanced technology candidates, offer pilot services, and transition Leading Edge Services (LES) technology to DISA. (\$ 2.596 Million)

(U)

FY1999 Plans:

•

Transition management: Provide programmatic integration management and engineering support through the DARPA/DISA Advanced Information Technology Systems (AITS) Joint Program Office (ADIPO) to identify and evaluate advanced technology candidates, offer pilot services, and transition LES technology to DISA. (\$ 1.500 Million)

(U)

FY2000 Plans: Not Applicable.

(U)

FY2001 Plans: Not Applicable.

(U)

Other Program Funding Summary Cost: Not Applicable.

(U)

Schedule Profile:

Plan  
Sep 98  
Sep 99

Milestones  
Identify and evaluate advanced technology candidates to DISA.  
Complete programmatic integration management and engineering support to ADIPO.

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RDT&E, Defense-wide					Sensor and Guidance Technology						
BA3 Advanced Technology Development					PE 0603762E						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost	
Total Program Element (PE) Cost	160,881	213,154	221,197	213,893	228,086	257,082	248,096	258,296	Continuing	Continuing	
Guidance Technology SGT-01	35,286	33,600	26,766	22,731	22,633	35,764	36,764	39,764	Continuing	Continuing	
Aerospace Surveillance Technologies SGT-02	19,987	68,855	73,511	72,729	73,517	93,486	80,500	87,500	Continuing	Continuing	
Air Defense Initiative SGT-03	20,170	33,500	40,350	30,680	35,460	35,000	38,000	38,200	Continuing	Continuing	
Sensor and Exploitation Systems SGT-04	85,438	77,199	80,570	87,753	96,476	92,832	92,832	92,832	Continuing	Continuing	

(U) **Mission Description:**

(U) The Sensors and Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing the system oriented technologies necessary to enhance sensor and weapon system accuracy and capability to meet current and emerging threats. Four projects are funded in this program element: Guidance Technology, Aerospace Surveillance Technology, the Air Defense Initiative, and Sensors and Exploitation Systems.

(U) The Guidance Technology project is leveraging geolocation technologies to enhance the navigation and/or guidance packages of airborne platforms, ground vehicles and weapons. These improved systems will improve the accuracy and effectiveness of stand-off weapons, minimizing collateral damage while reducing the cost-per-kill.

(U) Aerospace Surveillance Technology programs are developing technologies to improve the accuracy and timeliness of surveillance systems in all weather, in hostile reception environments, and when necessary, in a covert manner. The six programs funded by this project exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, high performance computing and low cost micro-electronics technologies.

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		Sensor and Guidance Technology
		PE 0603762E

- (U) The Air Defense Initiative is an on-going activity whose overall goal is to reduce the proliferating cruise missile threat and enhance the survivability of US assets in the face of enemy electronic countermeasures.
- (U) The objective of the Sensors and Exploitation Systems project is to provide the warrior with situational awareness and battlefield dominance by developing key sensor technologies; providing near-real-time exploitation of imagery data; and semi-automated target recognition and tracking.
- (U) Program Change Summary: (In Millions)
- |                             | <u>FY1998</u> | <u>FY 1999</u> | <u>FY 2000</u> | <u>FY 2001</u> |
|-----------------------------|---------------|----------------|----------------|----------------|
| Previous President's Budget | 167.184       | 213.154        | 232.646        | 204.718        |
| Current Budget              | 160.881       | 213.154        | 221.197        | 213.893        |
- (U) Change Summary Explanation:
- FY 1998 Decrease reflects reprogrammings for general reductions in PL 105-56, inflation transfer and SBIR.  
FY 2000 Reduction reflects reduced Agency emphasis on the Air Defense Initiative.  
FY 2001 Increase reflects increased Agency emphasis being placed on Sensors and Exploitation Systems.

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BA3 Advanced Technology Development					PE 0603762E, Project SGT-01						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Guidance Technology SGT-01	35,286	33,600	26,766	22,731	22,633	35,764	36,764	39,764	Continuing	Continuing	

(U) Mission Description:

(U) Fire-and-forget stand-off weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. The achievement of these characteristics in an integrated system is the goal of this program. The Global Positioning System (GPS) Guidance Package (GGP) technologies funded in this project are applicable for both new or retrofit guidance/navigation packages for a variety of airborne platforms, ground vehicles, surface-to-surface standoff weapons and air-to-surface weapons. Additional thrusts are also included in this project to increase the robustness of precision GPS navigation; to increase the versatility of navigation systems applications by developing micro-electromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation (Advanced Tactical Targeting Technology Program).

(U) GGP tightly integrates a miniature GPS receiver and an all solid state, low cost, navigation-grade, interferometric fiber optic gyroscope (IFOG) based miniature inertial measurement unit (MIMU) with an advanced navigation computer into a low cost (\$15,000), precision navigation system. GGP Phase I addressed the technology issues involved in: (1) miniaturizing navigation grade inertial measurement units (IMUs) into a compact, manufacturable configuration; and (2) developing a multi-channel-on-chip, high dynamics GPS receiver. A Memorandum of Agreement (MOA) has been signed and implemented to demonstrate a Phase 1 unit on an Army Fire Support Team Vehicle (FIST-V). Successful demonstrations were conducted at Redstone Arsenal in June 1995 using a M981 FIST-V. Successful demonstrations also were conducted on an F/A-18. These tests assessed the performance of tightly coupled systems in high dynamics and validated Phase 1 design scenarios. GGP Phase 2 requirements place more stressing demands on performance of MIMU components and call for further reductions in size, power and weight. An MOA has been signed with the Program Executive Officer, Tactical Missiles, Army Missile Command. Potential applications include the Multiple Launch Rocket System and ATACMS. Another Memorandum of Agreement (MOA) has been signed with the Program Executive Office, Ground Combat and Support Systems, and the Army Tank and Automotive Command.

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(U) The Global Positioning Experiments (GPX) will improve GPS receiver robustness by increasing its ability to operate effectively in the presence of enemy jamming or countermeasures. First, an all-in-view Miniature GPS Receiver (MGR) chipset will be upgraded to demonstrate very low power precision direct GPS signal acquisition by employing a unique very low power, greater than 10,000 correlator, fast acquisition integrated circuit and high performance clock. Operation with precision P(Y) GPS code signals increases the MGRs robustness to jamming. An additional GPX thrust is demonstration of a pseudolite concept which would sustain the availability of GPS signals in the presence of enemy jamming. This thrust includes two parts. The first is demonstration of Keplerian orbit predictions which show that only software modifications are needed for GPS user receivers. The second part provides for the design, development, implementation and demonstration of a low cost, all digitally controlled GPS adaptive phased array receiver antenna. This type of antenna eliminates coherent, precision matched analog antenna components and eliminates the need for antenna recalibration in stressing military environments.

(U) The Micro-Electromechanical Sensor Inertial Navigation System (MEMS INS) program will improve the silicon based, inertial sensors (gyros and accelerometers) developed in the MEMS technology program and integrate them with navigation software into a low power, small, light weight, low cost, tactical grade (1.0 degree per hour to 10 degrees per hour drift rate) INS. In addition to handheld applications, the MEMS INS will be generic for insertion/embedding into other military systems. MEMS INS Phase 1 will perform the following: (1) design and develop higher performance appropriate MEMS inertial gyroscope and accelerometer sensors, (2) select and refine foundries/foundry processes, (3) design the mechanical subsystem, and (4) select/refine the navigation software and perform INS simulations of the modeled sensors. Phase 2 will develop the MEMS inertial sensors brassboard, integrate them into a MEMS INS and demonstrate the brassboard in the field. Phase 2 will also model platform characteristics to insure platform vibration harmonics do not create bias terms on the coriolis force sensors.

(U) The Advanced Tactical Targeting Technology (AT3) program will demonstrate a passive tactical targeting system for the lethal suppression of enemy air defenses (SEAD). Today's threat radar targeting systems employed for SEAD fail to provide the rapid and accurate emitter geolocation needed to replace dedicated anti-radiation missiles (ARM) with generic, shoot-to-coordinate, smart weapons (e.g., JDAM or JSOW). The targeting system must negate emitter shutdown tactics now employed to defeat ARM guidance and enable simplified ordnance inventories. Generation and distribution or near real-time (e.g., seconds) comprehensive, and highly precise location of threat radars to all theater combatant aircraft is required without deploying any extra, SEAD dedicated, emitter collecting platforms. AT3 will accomplish this by widely deploying emitter collection packages hosted on existing airborne platforms, including combatant aircraft. AT3 will integrate (fuse) in real-time the distributed multi-platform emitter collections using existing or planned tactical (narrowband) radios with advanced network management (data packets) and signal processing. Additionally, to achieve the necessary wide deployment, AT3 self contained collection packages must impose negligible burden on their airborne hosts and be available at affordable prices. Enabling technologies now in development at DARPA will be used, including highly agile digital receivers packaged in multichip modules (MCMs), highly precise tactical clocks, tightly coupled integrated GPS/INS

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packages and advanced highly dynamic data fusion network management capabilities. Critical system advancements are (1) generating the commonly registered, theater-wide absolute doppler corrections to collected data and (2) managing the extraordinarily dynamic real-time data network including individual user kinematics and a changing aggregate participating user population.

(U) The Autonomous Landing Guidance (ALG) Technology Reinvestment Project (TRP) follow-on operational assessment program will install and demonstrate a low-visibility, day-night, precision approach and landing capability that is compatible with Air Mobility Command (AMC) operational requirements. The program will leverage work accomplished under the DARPA ALG TRP. The system (94GHz radar, Forward Looking Infrared (FLIR), Head-Up Display (HUD)) developed under the ALG TRP will be installed in a USAF C-130H3.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Continued fabrication and began integration of GGP Phase 2 hardware and software. (\$ 6.000 Million)
- Designed circuits and power management techniques for the direct precision GPS code, low power, robust MGR. (\$ 10.000 Million)
- Designed the GPS adaptive antenna array, signal processing and control functions for the MGR. (\$ 7.815 Million)
- Demonstrated proof of concept MEMS devices. (\$ 3.290 Million)
- Initiated Advanced Tactical Targeting Technology (AT3) analysis, design and development. (\$ 7.561 Million)
- Completed ALG system installation on C-130H3, and conduct operational flight tests. (\$ 0.620 Million)

(U) FY1999 Plans:

- Perform final integration and testing of GGP units; deliver eight units. (\$ 4.000 Million)
- Fabricate and demonstrate the robust MGR. (\$ 4.600 Million)

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- Conduct final design reviews and complete integration of adaptive GPS receiver antenna and signal processing. (\$ 4.000 Million)
- Iterate MEMS foundry inertial sensor fabrication and initiate preliminary sensor testing. (\$ 9.000 Million)
- Complete AT3 design and conduct critical component demonstrations. (\$ 12.000 Million)
- (U) **FY2000 Plans:**
  - Continue demonstration and evaluation of the robust MGR. (\$ 2.000 Million)
  - Test and evaluate GGP Phase 2 units. (\$ 3.000 Million)
  - Refine and reevaluate elements of the pseudolite network. (\$ 1.000 Million)
  - Complete MEMS integration with navigation software and demonstrate INS operation. (\$ 10.666 Million)
  - AT3 brassboard fabrication and ground tests. (\$ 10.100 Million)
- (U) **FY2001 Plans:**
  - Complete AT3 ground test and conduct flight tests. (\$ 8.000 Million)
  - Complete MEMS vibration compensation model development. (\$ 14.731 Million)

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(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Sep 98	Begin design of the Advanced Tactical Targeting Technology (AT3).
Sep 98	Conduct preliminary design review of MEMS gyro/accelerometer.
Oct 98	Complete critical design reviews and begin fabrication of an adaptive GPS antenna array.
Nov 98	Demonstrate full function, low power miniature GPS receiver breadboard.
Jan 99	Deliver brassboard MEMS gyros.
Apr 99	Complete preliminary design of the AT3.
Jun 99	Deliver GGP units to the Government.
Aug 99	Select MEMS INS development efforts.
Sep 99	Deliver engineering model MEMS accelerometers.
Sep 99	Complete integration of an adaptive GPS antenna array.
Nov 99	Complete AT3 critical component demonstrations and begin brassboard fabrication.
Feb 00	Complete test and evaluation of GGP Phase 2 units.
May 00	Complete integrated demonstration of miniature GPS receiver and adaptive antenna.
Sep 00	Complete AT3 brassboard fabrication and begin ground tests.
Sep 00	Test and deliver brassboard MEMS inertial navigation system.
Dec 00	Complete AT3 ground tests.
Mar 01	Complete Government evaluation of the robust MGR.
May 01	Initiate AT3 flight tests.
Sep 01	Complete MEMS vibration compensation model development.
Nov 01	Complete AT3 flight tests.

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COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Aerospace Surveillance Technologies SGT-02	19,987	68,855	73,511	72,729	73,517	93,486	80,500	87,500	Continuing	Continuing

(U) Mission Description:

(U) This project funds space and airborne sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a covert manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, low-power high-performance computing, and low-cost micro-electronics to develop advanced surveillance systems. Surveillance is not an end to itself but rather an enabler for force protection and precision strike. Therefore a key component of this program is the development of a comprehensive sensor-to-shooter architecture.

(U) The Millimeter Wave Targeting & Imaging System (MMWTIS) program will develop and demonstrate the targeting and imaging technologies to enable a low-cost, all weather, day/night precision targeting approach against moving or stationary targets at millimeter wave (W band) frequencies. The technologies investigated will include active and passive techniques to achieve high resolution targeting (low CEP) and imaging (1-3 m). An objective system could be used for weapons targeting, high resolution imagery, and battle damage assessment. This program will pursue advanced radar algorithms and sparse aperture concepts, and intelligent incorporation of miniaturized monolithic integrated circuit (MMIC), advanced W band power amplifier technology, radio frequency photonics technology and low power high performance computing.

(U) The DARPA Radio Frequency (RF) Tags Program will develop technology to allow airborne radars (both Moving Target Indication (MTI) and Synthetic Aperture Radar (SAR)) to communicate directly with ground devices for identification of friendly assets, to covertly communicate information from ground sensors to the platform, and to correct for errors in the radar-determined location of targets. It is envisioned that RF tags will greatly enhance the utility of airborne radar systems by aiding in the identification of unfriendly targets via the timely communication and fusion of unattended ground sensors (UGS) data with the radar picture. Tags will also help to identify friendly assets by adding a unique identification (ID) to their radar return that is fused to the radar picture. Airborne radars are also being considered for targeting stationary and moving targets. By combining a Global Positioning System (GPS) receiver with an RF tag, and using the tag to transmit the tag's geographic coordinates to the platform, the location of targets within a certain distance of the tag can be determined with great accuracy. While the immediate

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RF Tags Program goals are to enhance the utility of airborne radars, it is envisioned that there are significant space based radar applications of this technology. A key goal of the RF Tags Program is a system with very low probability of detection, intercept and exploitation that is secure against an adversary with detailed knowledge (except for crypto key information) and moderate technical capability. The objective of the DARPA RF Tags Program is to design and demonstrate three types of tags: an ID only tag, a low data rate tag (suitable for low data rate unattended ground sensors) and a high data rate tag (suitable for image transmission).

(U) The Adaptive Spectral Reconnaissance Program will develop a new generation of airborne reconnaissance systems based on spectrally adaptive imaging sensors. Because it is particularly suited to real time detection processing, spectral technology will enhance the ability to conduct directed wide area search for high value targets from both manned and unmanned airborne platforms without substantially increasing demands on communications infrastructure or ground based data analysts. This is done by transferring the hyperspectral exploitation requirement to an on board data processor. This program will, in conjunction with Army funding, develop a day/night system using both reflected sunlight and thermal infrared emissions. This system will be demonstrated on manned platform and an Unmanned Air Vehicle (UAV) platform.

(U) The Tactical Radar Program will develop a new generation of aerospace-based radars tailored to support theater military operations. The program's first goal is development of an aerospace-based Ground Moving Target Indicator (GMTI) capable of detecting mobile-missile launchers and other high value ground threats deep in denied territory, beyond line-of-sight of airborne air surveillance assets. This includes developing techniques to enable an aerospace-based radar to function in a mode of operation enabling simultaneous collection of both Synthetic Aperture Radar (SAR) imagery and GMTI data, at very high area rates, without performance degradation. The second goal is development of techniques to correlate discontinuous GMTI target tracks ( more than 4 min track durations, with intervening gaps of less than 15 min) produced by aerospace-based radar. The third goal is development of techniques to exploit aerospace-based SAR imagery for near-real-time (NRT) derivation of high-precision geolocation estimates ( less than 3 meter Total Location Error) for ground targets, using high-fidelity Digital Terrain Elevation Data (DTED Level-5) in conjunction with SAR imagery. In FY99, the Tactical Radar program is being assimilated by the Discoverer II program because of the close, inherent relationship of the two programs, and the dependency of the Discoverer II program on the success of technical advances being pursued by the Tactical Radar effort.

(U) The Discoverer II program is a Defense Advanced Research Projects Agency (DARPA), Air Force and National Reconnaissance Office (NRO) joint initiative to develop and demonstrate an affordable space-based radar (SBR) with Ground Moving Target Indication (GMTI) and Synthetic Aperture Radar (SAR) imaging capabilities that will revolutionize reconnaissance, surveillance and precision geolocation support to the tactical warfighter. Discoverer II is the direct descendant of the DARPA STARLITE initiative. In January 1998, the DSB Task Force on Satellite Reconnaissance issued its report. The Task Force recommended that a modified STARLITE program be initiated, as a "Military Space Radar

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Surveillance Program," in an effort to achieve broad-area, all-weather, near-continuous radar access that could be integrated with military operations. Two central findings of the Task Force were that an on-orbit demonstration would likely be needed; and, that a technical risk reduction program should be undertaken in advance of the demonstration to bring leading edge, higher risk technologies to bear to both meet warfighter needs at lower cost, and to enhance system maturity and thereby facilitate a more direct and rapid transition to a follow-on operational system.

(U) Discoverer II is a staged technology demonstration program. In the first phase industry will conduct detailed trades necessary to define both an affordable objective space-based radar system for the 2008 timeframe and a demonstrator system for the 2003 timeframe that shows the ability to achieve the proposed objective capability. Concurrent with the performance of trade studies by Discoverer II system integration contractors, results of the Tactical Radar program will be exploited, and other risk reduction initiatives will be undertaken to ensure Discoverer II system development can be pursued with acceptable risk. Specifically, the technologies to be pursued include: 1) developing a low-cost, multi-mode (GMTI/SAR) space-qualified electronically scanned antenna, 2) developing low power Microelectromechanical Systems (MEMS) for scanning of radar modules (10x reduced power requirement), and 3) sparse band processing for data compression allowing on-ground processing with .5Gbps links, and Automatic Target Recognition (ATR) quality (.5m) range profiling. The proposed satellite system will also use an interferometric synthetic aperture radar (IFSAR) capability to produce high-accuracy digital terrain elevation data (DTED) to support both battlefield visualization (BV) and precision guided munitions (PGM) targeting (3m or less geolocation accuracy theater wide). If industry trade studies, informed by the results of the Discoverer II risk reduction initiatives, show an affordable objective system is achievable, phase two will be entered: the actual building and flying on-orbit of two GMTI/SAR technology demonstration satellites. That demonstration will validate the technical feasibility of: space-based GMTI detection and tracking, and moderate resolution SAR imaging, using a small, low-mass, beyond-current state-of-the-art radar antenna; tactical warfighter dynamic tasking of overhead GMTI and SAR collection; near-real-time, direct downlink to theater of overhead GMTI and SAR collection, using tactical ground stations otherwise planned for use with our U-2 and UAV airborne platforms; and, collection of high-resolution terrain mapping data, anywhere around the globe. A "go-ahead" decision to proceed with the acquisition of an operational capability, and initiate a low-cost, low-risk, mini-EMD effort for the follow-on system, would be made after the completion of the Discoverer II demonstration program, sometime after FY04.

(U) The Novel Antennas Program applies crossover technologies to produce small, light-weight systems with low power requirements that are capable of locating specific emitters in a dense interference environment. The program will leverage major investments already made in photonics, antennas and space-time adaptive array processing with the latest advances in digital receivers, signal processors, and devices employing superconductivity. Both centralized and distributed sensor/array architectures will be explored. Prior to FY 1999 the program funding was distributed amongst the component technology development programs.

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(U) The Counter-Underground Facilities project will identify, research, develop and demonstrate high leverage technologies for locating, characterizing and functionally neutralizing underground facilities. Such structures are increasingly employed to hide manufacture and storage of offensive weapons, including chemical, biological and nuclear weapons. The project will begin by investigating critical phenomenological unknowns related to observable signals generated by underground facilities and the backgrounds in which such signals would be detected. A series of experiments would then ensue to resolve the critical unknowns and deepen the national capability to model such structures and predict which, if any, reliable signals might be present and detectable for representative targets. Sensor techniques would then be developed and demonstrated to exploit these reliable signatures. Both remote and proximal types of technologies will be studied. Candidate technologies include, but are not limited to, laser vibrometry, low frequency electromagnetics, multi/hyperspectral imaging, seismic/acoustic imaging, laser velocimetry and micromechanical systems for close access tagging and sensing.

(U) Non-Linear Radar Communications Mapper (NLRCM): High valued camouflaged targets usually have radio transceivers for command and control purposes. To avoid detection, an attempt is frequently made to operate these radios primarily in the receive mode and to minimize radio transmission. Exploiting nonlinearities in the radio receiver, it may be possible to design a radar to detect and locate these radios while they are in the receive mode or possibly while they are in a standby mode. It has been postulated that if a radio receives a high powered tone, due to nonlinearities in the receiver, it will reradiate an intermod of the received frequency and the frequency to which it is tuned. Alternatively, if two tones are received, the radio will transmit an intermod of the two received frequencies. The radar systems concept is to develop either an airborne or satellite pulse CW radar to detect locate and map the locations of radio equipment based upon their nonlinear intermod behavior. This program will exploit legacy communications technology developed under the Novel Antennas program into various application domains.

(U) The Large Millimeter Wave Telescope (LMT) is a Congressionally mandated program to develop the largest (50 meter aperture) fully steerable millimeter wave radio telescope built to date. The design features a sophisticated laser metrology system to maintain precise alignment of the optics, and real time closed loop adaptive control actuator system to maintain a near-perfect parabolic surface at all pointing angles and under most environmental conditions.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- The Millimeter Wave Targeting & Imaging System (MMWTIS) program - Completed greybeard panel review and program assessment which shifted program from Passive MMW to Millimeter Targeting and Imaging. Issued Solicitation, evaluating and

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awarding concept development efforts. Initiated 94 GHz signature measurements and analysis. Refined requirements and subsystem and technical specifications for transmitter and component technology. Refining 3D SAR algorithms. (\$ 4.600 Million)

- Radio Frequency (RF) Tags program - Performed analyses for multiple concepts of operation to include remote communications of sensor data from unattended ground sensors, data communications from Special Operations Forces (SOF), geo-registration of Synthetic Aperture Radar (SAR)/Moving Target Indicator (MTI) imagery, and communications of geolocation and other data between dispersed operating units. System design for each operational concept was conducted, and fabrication of brassboard RF tags, modifications to airborne SAR/MIT processors and ground stations were completed. Tests were performed with the Joint Surveillance Target Attack Radar System (JSTARS) to define an RF tag system architecture and functionality. Flight tests were conducted with SAR tag designs to demonstrate a SAR tag and to design signal and image processing software. Development was initiated for ID-only and data extraction tags to be tested with SAR and MTI platforms. A CONOPS/Requirements study was completed to establish the system CONOPS, utility, value added and requirements, and a study of radar platform characteristics was initiated to evaluate suggested platforms. (\$ 5.108 Million)
- Adaptive Spectral Reconnaissance program - Developed system concepts and sensor specifications. Prototyped system (NVESD Twin Otter) in flight, collecting data. Coordinated concept verification data collections occurring with Air Force Research Lab, Naval Research SITAC, and Aerospace Corporation. Completed concept definition to include algorithm development, mission utility analysis, operational concept, sensor specification development, test plan preparation, and data analysis. Established transition partners with Army (Aerial Recce Low/Aerial Common Sensor PM) in terms of outyear POM and validated developed requirement. Worked transition issues with Air Force UAV Battle Lab and Air Force Recce SPO. (\$ 3.000 Million)
- Tactical Radar Program - Developed initial algorithms supporting aerospace-based ground moving target indication (GMTI) using low-cost, light-weight, multiple phase center/receive channel antenna and 548 Mbps CDL. Established feasibility of high-throughput, GMTI collection (>800 km2/sec collection rate, sustained over >6 min). Established feasibility of achieving <10 kph Minimum Detectable Velocity (MDV) for ground targets. Developed initial algorithms supporting GMTI collection performance while simultaneously collecting undergraded synthetic aperture radar (SAR) phase history data, in 3m resolution mode. Established feasibility of achieving discontinuous GMTI track correlation, and developed initial algorithms enabling GMTI target tracking. Conducted selective/limited GMTI data collection using existing airborne SAR platforms. (\$ 4.395 Million)

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- The Large Millimeter Wave Telescope (LMT) completed critical system design. Access to site was prepared with geological surveys performed for antenna placement and foundation specifications. Comprehensive environment measurement program initiated. Initiated panel design and prototype development. Laser metrology design initiated. (\$ 2.884 Million)

(U) FY1999 Plans:

- Millimeter Wave Targeting & Imaging System (MMWTIS) – Complete concept development studies. (\$ 1.000 Million).
- Radio Frequency (RF) Tags program - Complete development and testing of ID-only RF Tags for use with SAR and MTI airborne radar platforms. Continue design of data extraction tags for low data rate communications applications. (\$ 10.000 Million)
- Adaptive Spectral Reconnaissance program - Continue system development. Develop prototype system and demonstrate prototype system in a range of operational scenarios. Continue data collections with concept verification platform (Twin Otter). Refine algorithms. (\$ 5.000 Million)
- Discoverer II program – Commence Phase One: Award multiple system integration (SI) contracts. Support SI contractor trade studies to define both an affordable objective space-based radar system for the 2008 timeframe and a demonstrator system for the 2003 timeframe that shows the ability to achieve the proposed objective capability. Develop detailed engineering designs, productivity data, and performance analysis substantiating technical feasibility and cost estimate of a space-qualified electronically scanned antenna (ESA). Conduct risk reduction activities with the aim to demonstrate adequate MDV detection performance; high-throughput GMTI; GMTI target tracking capability; acceptable probability of detection/false alarm performance; data based feasibility of simultaneous Ground Moving Target Indication/Synthetic Aperture Radar (GMTI/SAR) mode; and ground moving target identification and characterization. (\$ 33.000 Million)
- Novel Antennas program will pursue data collection, and will demonstrate algorithm performance against emitters in a realistic interference environment. Distributed architectures will be developed and implemented, supporting prototype hardware will be developed and demonstrated, and algorithm performance will be evaluated. The integrated system design for the operational system will be developed, as will a photonic antenna, and system performance will be demonstrated. An experiment will also be conducted to determine the utility/synergy of close access, distributed collection capability into a distributed architecture.

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Networked and single hand-held sensors, which leverage software reprogrammable radio technology, will be employed to assess the utility of single and networked node architectures. (\$ 13.653 Million)

- Counter-Underground Facilities program will convene a signal hypothesis working group consisting of the nation's experts in a variety of disciplines critical to the counter underground facility problem including seismology, acoustics, low frequency electromagnetics, geology, and others. The working group will identify and model critical underground facility signatures, propagation phenomenology and backgrounds. It will also identify critical unknowns and define experiments to resolve them. Experiments, data analyses, and detailed modeling activities will begin. (\$ 6.202 Million)

## (U) FY2000 Plans:

- Radio Frequency (RF) Tags program - Continue the development and testing of data extraction RF Tags for both low and high data rate applications with SAR and MTI radar platforms; Demonstrate multiple RF Tags in an operational exercise with both SAR and MTI airborne radar platforms. (\$ 7.311 Million)
- Adaptive Spectral Reconnaissance Program - Complete prototype system demonstration and transition to service partners. (\$ 4.000 Million).
- Discoverer II program - Conduct rolling SI contractor down-select, initially to two contractors, and ultimately to a single SI contractor to complete detailed system design. Acquire SI contractor trade study results substantiating affordability of a follow-on, objective system; acquire preliminary SI designs for both an affordable objective space-based radar system for the 2008 timeframe and a demonstrator system for the 2003 timeframe that will validate the feasibility of achieving the proposed objective capability. Continue development of high-resolution DTED geolocation concepts and their insertion into on-going precision guided munitions (PGM) programs. Extend existing exploitation programs in aided target recognition, automated tasking, and dynamic database development as they pertain to Discoverer II. Further refine signal processing and target tracking algorithms to enhance signal-to-clutter performance. (\$ 51.700 Million)
- The Novel Antennas program - The Novel Antennas program will transition technology to a ground based military system for real-time urban operations. Adjunct platforms will be pursued for technology transfer and system integration. (\$ 1.500 Million)

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- Counter-Underground Facilities program - The Counter-Underground Facilities program will continue analysis and experimentation on key observables and backgrounds. Sensor system studies will be performed to identify critical technology initiatives. Sensor and technology development will commence. (\$ 9,000 Million)
- (U) FY2001 Plans:
- Radio Frequency (RF) Tags program - Continue the development and testing of data extraction RF Tags for both low and high data rate applications with SAR and MTI radar platforms; Continue to demonstrate multiple RF Tags in an operational exercise with both SAR and MTI airborne radar platforms. (\$ 6.629 Million)
  - Discoverer II program - Commence Phase Two: SI contractor completes detailed design of both an affordable objective space-based radar system for the 2008 timeframe and a demonstrator system for the 2003 timeframe that will validate the feasibility of achieving the proposed objective capability. Conduct CDR for system detailed designs. Initiate procurement of long-lead items for two GMTI/SAR demonstration satellites. Continue on-going signal processing and target tracking algorithm development. Continue software demonstrations. (\$ 53.100 Million)
  - The Counter Underground Facilities program will continue analysis and experimentation on key observables and backgrounds. Sensor system studies will be performed to identify critical technology initiatives. Sensor and technology development will commence. (\$ 8,000 Million)
  - Non-Linear Radar Communications Mapper Program: Perform assessments of nonlinear radar phenomenon to detect critical mobile targets under camifloage and underground facilities via non-linear scattering from their communications equipment and initiate system concept development. (\$ 5,000 Million)



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(U) Other Program Funding Summary Cost: (In Millions)

Passive Radio Frequency Tags				
Source	FY 1998	FY 1999	FY 2000	FY 2001
DARO	1.0	-	-	-
Adaptive Spectral Reconnaissance				
Source	FY 1998	FY 1999	FY 2000	FY 2001
DARO	4.0	-	-	-
Army	-	4.0	-	-
Discoverer II				
Source	FY 1998	FY 1999	FY 2000	FY 2001
NRO	14.0	14.9	29.2	54.2
Air Force	-	14.9	29.2	68.5

(U) Schedule Profile:

Plan   Milestones

Millimeter Wave Imaging System:

Dec 98   Complete concept development, W band targeting lab demonstrations, initiate concept of operations development.

Radio Frequency (RF) Tags:

Apr 99   Complete Radar Platform Analysis.  
Jun 99   Complete ID-only Tags, radar/processing modifications.  
Jun 00   Develop and test data extraction RF Tags.  
Jun 01   Demonstrate multiple RF Tags in an operational exercise.

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Adaptive Spectral Reconnaissance:

- Aug 98 Awarded system development contract.
- Nov 99 Delivery of spectral system.

Tactical Radar:

- Aug 98 IOC for algorithm chain processor.
- Sep 99 Demonstrate advanced GMTI performance using algorithm chain processor.
- Sep 99 Demonstrate simultaneous GMTI/SAR performance using algorithm chain processor.
- Sep 99 Demonstrate GMTI target tracking using algorithm chain processor.

Discoverer II:

- Oct 98 Release solicitation for system integration proposals.
- Dec 98 Award multiple System Integration (SI) design/integration/demonstration contracts.
- Feb 99 Begin detailed design of full-scale ESA and build subscale ESA test article.
- Apr 99 Begin initial round of SI contractor Interim Evaluation Reviews (IERs).
- Jan 00 Complete IER #2 for all SI contractors.
- Jan 00 Down-select to two SI contractors.
- Sep 00 Complete IER # for two remaining SI contractors.
- Sep 00 Down-select to a single SI contractor.
- Oct 00 Begin procurement of long-lead items.
- Apr 01 CDR: Final design (objective and demonstration systems).
- Sep 01 Begin software demonstrations.
- Nov 01 Begin satellite subsystem assembly.
- Dec 01 Begin ground station processing software integration.
- Sep 02 Begin satellite #1 integration.
- Mar 03 Complete Satellite #1 space qualification testing.
- Sep 03 Launch Demonstration Satellite #1.
- Nov 03 Launch Demonstration Satellite #2.
- Sep 04 End on-orbit demonstration.

Adaptive Spectral Reconnaissance:

- Sep 98 Award build contract for prototype system.
- Feb 99 Complete concept verification flights.
- Feb 00 Delivery of prototype tactical spectral system.
- Dec 00 Complete testing of tactical spectral system.
- May 00 Transition tactical spectral system to services.

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Novel Antennas:

Jan 99 Complete fixed site collation.  
Apr 99 System specification complete.  
Sep 99 Demo system completed.  
Apr 00 Final data collection.  
Jul 00 Wideband link demonstration.  
Sep 00 Transition.

Counter-Underground Facilities:

Nov 98 Initiate signal hypothesis team.  
Jan 99 Preliminary validation experiments.  
Jan 00 Complete development of key models.  
Jun 00 Complete preliminary tests.  
Aug 01 Finalize sensor recommendations.

Non-Linear Radar Communications Mapper Program:

Aug 01 Complete initial assessment of non-linear scattering of communications equipment.

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COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Air Defense Initiative SGT-03	20,170	33,500	40,350	30,680	35,460	35,000	38,000	38,200	Continuing	Continuing	

(U) Mission Description:

(U) This Project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. These programs include the Synthetic Aperture Radar Electronic Counter-Countermeasures (SAR ECCM) Program, the Low-Cost Cruise Missile Defense (LCCMD) Program, the Air Directed Surface-to-Air Missile (ADSAM) Program, and the Adjunct Airborne Early Warning (AEW) program.

(U) The SAR ECCM Program will develop techniques to make U.S. Synthetic Aperture Radar (SAR) systems less vulnerable to intentional enemy jamming or deception. SAR systems have become one of the most widely used broad area surveillance systems. They are critically important to the development of battlespace awareness and their jamming and/or deception could seriously degrade U.S. warfighting capability. The SAR ECCM program will determine the military impact of various SAR jamming techniques and develop countermeasures against the highest priority threats.

(U) The Low Cost Cruise Missile Defense (LCCMD) program employs emerging missile seeker technologies to provide cost effective approaches to defeat proliferated asymmetric airborne threats. These threats include cruise missiles, unmanned air vehicles capable of conducting surveillance or jamming operations, as well as slow, low-flying manned aircraft such as helicopters and fixed-wing aircraft capable of dispensing chemical or biological agents. Various seeker options will be investigated, focusing on the development of very low cost, highly capable seekers, and radar antennas, which can be integrated into a missile interceptor and deployed in large numbers.

(U) ADSAM: The purpose of this joint DARPA/AMCOM/USMC/AMRAAM program office project is to rapidly demonstrate enabling technologies and operational concepts to support the destruction of low flying, difficult to detect targets, such as cruise missiles. This project demonstrates the critical technologies required to destroy such difficult to detect targets beyond the line-of-sight and at the full intercept range of surface-to-air missile systems. This live fire demonstration program uses an elevated platform to provide target cueing and updates to Advanced Medium Range Air to Air Missiles (AMRAAM). These missiles are ground launched from modified High Mobility Multi-Purpose Wheeled Vehicles (HMMWV) developed by DARPA and AMCOM, known as the HUMRAAM. This demonstration program also supports the Marine's ongoing HUMRAAM program, called the Complimentary Low Altitude Weapons System (CLAWs), by allowing them to quickly progress from

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concept development through demonstration/validation in less than 1 year. Early successes with the HUMRAAM have led the Marines to include its further development and acquisition in their FY 2000 POM, and the Army to conduct two FY 1998 live fire tests.

(U) The Adjunct Airborne Early Warning (AEW) program will demonstrate the feasibility of installing ultra-lightweight radar technology in UAVs. The radar would provide a lower cost (factor of 20) continuous air surveillance of low intensity areas such as no-fly zones, thus supplementing AWACS and E2-C, and reducing the requirement for such large numbers of manned aircraft. The key technologies to be used are solid state transmitters, composite lightweight integrated antennas, and high speed signal processing. A system design will be explored which uses common components to perform the AEW mission (at reduced ranges appropriate to this concept), and to provide air-to-ground modes which support networking concepts which reduce cost and enable precision moving surface target engagement.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- SAR ECCM: The study panel updated their analyses of intelligence, surveillance and reconnaissance (ISR) SAR ECM vulnerability and candidate ECCM technique performance. Data to support analysis and algorithm design was collected with a representative ISR SAR system supported by DARPA's Sensor Emulation Platform, (SEP) Program. Analysis of ECCM techniques applicable to the SEP class of ISR radars has begun. (\$ 5.238 Million)
- Low Cost Cruise Missile Defense (LCCMD): The risk reduction phase for a Ka-band pulse doppler radar seeker employing a Micro-Electro-Mechanical System (MEMS) Electronically Steered Array (ESA) was initiated. Design efforts were initiated for a captive flight worthy Ka-Band noise correlation radar seeker and the Ka-Band pulse doppler radar seeker. Both seeker developments will lead to fabrication and flight test. The noise correlation radar seeker passed a system design review milestone. Additionally, four contractor teams were selected to begin the preliminary design and analysis for advanced low cost seekers to defeat an expanded array of asymmetric airborne threats. (\$ 10.060 Million)
- ADSAM: Two successful "dry runs" of the complete ADSAM architecture were conducted in 2nd QTR FY 1998. During the 3rd QTR two tests were conducted in which HUMRAAM missiles were launched against low-flying cruise missile targets. A live fire test was accomplished during the 4<sup>th</sup> QTR using a live warhead AMRAAM missile. Following completion of this demonstration, the residual

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assets (2 HUMRAAMs with associated hardware and software) were provided to the Marine Corps to support their ongoing Complimentary Low Altitude Weapons System (CLAWS) program. (\$ 4.872 Million)

(U) FY1999 Plans:

- SAR ECCM: The hardware implementation of candidate SAR ECCM algorithms applicable to Sensor Emulation Platform (SEP) will commence. Selected ECCM techniques will be implemented for mitigating low-level ECM threats in both the analog (front end) and image domain portions of the radar. Additional data will be collected to support technique development. A laboratory demonstration of the selected ECCM products will occur. Design efforts and test planning will get underway in preparation for a proof of principle demonstration scheduled for FY 2000. (\$ 7.000 Million)
- LCCMD: The noise correlation radar seeker will complete fabrication and laboratory ground testing. The MEMS ESA pulsed doppler radar will begin fabrication and laboratory testing. Alternate MEMS phase shifter and array fabrication technologies appropriate for a very large, lightweight, low-cost array will be developed. The four preliminary design and analysis efforts for advanced low cost seekers begun in FY 1998 will be completed. Two of the four designs will be selected to begin detailed design. Final design mods of a low cost, MALD-based interceptor to be used for live fire testing will be completed and the fabrication phase will begin. (\$ 23.500 Million)
- ADSAM: Modifications to the HUMRAAM developmental system will be completed. Assets will be transferred to the Marine Corps for field evaluation/exploration. Technical lessons learned, including software and hardware, will be transferred and implemented, if possible, to the air defense community for future ADSAM live fires with other missiles (Standard Missile, Patriot, etc) (\$ 3.000 Million)

(U) FY2000 Plans:

- SAR ECCM. The design and implementation of the selected ECCM techniques will be completed and integrated on-board the SEP. A proof-of-principle demonstration will be conducted with real-time in-flight jamming and processing. (\$ 9.050 Million)
- LCCMD: The noise correlation radar seeker will conduct captive flight testing to evaluate its performance against typical threat targets. The pulsed doppler radar seeker and the two seekers designs selected in FY 1999 will complete fabrication and laboratory testing. Two

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very large MEMS-based antennas will be fabricated to demonstrate performance and weight, power and cost reduction (40-60 times reduction in cost). Fabrication of the low cost interceptor will continue, with detailed live fire planning getting underway. (\$ 31.300 Million)

(U) **FY2001 Plans:**

- SAR ECCM: An operational real-time demonstration will be conducted with the modified SEP platform against a set of recognized and non-recognized ECM threats. The effectiveness of the DARPA developed ECCM techniques will be qualitatively evaluated by image analyst assessment of SAR image interpretability and quantitatively evaluated by using current state-of-the-art automatic target recognition (ATR) software. (\$ 5.000 Million)
- LCCMD: The noise correlation radar seeker test results analysis will be completed. The pulsed doppler radar seeker and the two seekers selected in FY 1999 will conduct captive flight testing to evaluate their performance against typical threat targets. Fabrication of the low cost interceptor will be completed. The most promising seeker will be integrated into the low cost interceptor for a FY 2002 live fire demonstration against anticipated threat targets. (\$ 20.680 Million)
- Adjunct AEW: Lightweight, low-cost antennas capable of supporting limited AEW and ground surveillance missions will be developed. Subarrays will be fabricated and laboratory tested. Integration and test planning will begin. (\$ 5.000 Million)

(U) **Other Program Funding Summary Cost:** Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
LCCMD:	
Sep 98	Noise Correlation Radar Seeker PDR
Dec 98	MEMS Pulsed Doppler Radar Seeker PDR
Jan 99	Alternate Large MEMS Array Approaches PDR

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Feb 00	Noise Correlation Radar Seeker Captive Flight Test Start
Aug 00	Large Array Fabrication Begins
Nov 00	Pulsed dropper & Advanced Seeker Captive Flight Testing Start
May 02	Live Fire Testing Start

**SAR ECCM:**

Jan 99	Algorithm/Hardware Implementation
Aug 99	Laboratory ECCM Demo
Aug 00	Field ECCM Demo

**Adjunct AEW:**

Oct 01	Begin development and testing of low-cost antenna subarrays
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BA3 Advanced Technology Development					PE 0603762E, Project SGT-04						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Sensor and Exploitation Systems SGT-04	85,438	77,199	80,570	87,753	96,476	92,832	92,832	92,832	Continuing	Continuing	

(U) Mission Description:

- (U) The development efforts described herein embody key sensor demonstrations and the exploitation of sensor products. These efforts, in conjunction with those described in Projects CCC-02 and SGT-02, seek to develop the systems needed to provide the warrior with situational awareness and precision targeting capability. The strategic goals of this project are to: develop key sensor technologies required to support dominant battlefield awareness, including sensors which can counter Camouflage, Concealment and Deception (CC&D); provide near-real-time, semi-automatic, exploitation of wide-area moderate (and high) resolution imagery; and provide semi-automated recognition and precision tracking of high value units and critical moving targets. These goals are being addressed by the Counter CC&D Program; the Semi-Automated Imagery Intelligence (IMINT) Processing (SAIP) Advanced Concept Technology Demonstration (ACTD); the Sensor to Shooter to Weapon (SSW); Moving and Stationary Target Acquisition and Recognition (MSTAR), Continuous Ground Vehicle Tracking (CGVT), Force Protection GMTI, and Moving Target Exploitation (MTE) Automatic Target Recognition (ATR) applications programs; Airborne Video Surveillance (AVS) program; and Surface Target Engagement (STE) program.
- (U) The goal of the Counter CC&D Program is to significantly enhance the military's capability to detect obscured targets hidden under natural and artificial camouflage. Specific goals include validation of Foliage Penetration (FOPEN) target detection capability (0.1 FA/sq.km max) using a FOPEN Synthetic Aperture Radar (SAR). The FOPEN SAR will be developed for demonstration on a manned platform (Army RC-12) providing inputs via narrowband tactical data links for ground image exploitation. A Ground Control and Display Subsystem (GCDS) is being developed to provide real time, remote operation of the FOPEN SAR, Automatic Target Detection and Cueing (ATD/C), and a Common Imagery Ground/Surface System (CIGSS)-compliant exploitation interface. The image exploitation processing of SAIP will be extended for FOPEN as well as Multi/Hyper Spectral Image (M/HSI) sensor input, geolocation and sensor fusion processing of images, and detection of time critical targets. The program will ultimately combine FOPEN Radar on the Global Hawk High Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) with other airborne sensors (e.g., the Senior Year Electro-optical Reconnaissance System on the U-2) and modes (GMTI/passive detection), and develop combined exploitation technologies for insertion into the CIGSS. Analyses will also be carried out to evaluate the capability for FOPEN Moving Target Identification (MTI) and Radio Frequency Intelligence (RFINT) for increasing the effectiveness of Counter CC&D on future system designs.

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(U) The Semi-Automated IMINT Processing (SAIP) ACTD will develop, test and transition to the operational user, automated algorithms and semi-automated tools that enhance the warfighter's capability to: process SAR, and later EO imagery; conduct wide-area search for Ground Order of Battle and Missile Order of Battle targets; perform rapid site modeling and site monitoring; and produce target reports in near real-time (< five minutes). Goals for the baseline system are: automatic target cueing and classification for a limited set of vehicles (10 targets); object level change detection; force recognition to the company level; and interactive target recognition and terrain delimitation. Goals for an enhanced system are: increasing the automatic target cueing and classification to 20 targets; site modeling and monitoring with EO and SAR; and addition of SIGINT cueing. An enhanced fielded system will further increase automatic target recognition to 30 targets.

(U) The goal of the Moving and Stationary Target Acquisition and Recognition (MSTAR) program is to achieve a major advance in Automatic Target Recognition (ATR) performance on SAR imagery through fundamental and innovative technology developments and to transition this technology to fielded systems with ATR requirements. The approach to detect stationary targets utilizes traditional ATR techniques to first determine suitable target candidates for image regions of interest (ROIs). A model-driven subsystem then refines these candidates by using a SAR signature prediction module to determine the true target ID of the ROI. To handle moving targets, one-dimensional model-based analysis of radar returns from multiple viewpoints will be used to perform identification. Other program goals include: significant advances in tools that include ATR capabilities to efficiently perform interactive image exploitation; development of rapid target model construction; collection and dissemination of high-quality databases of SAR signatures, development of resource management systems for surveillance and exploitation, and development and demonstration of ATR- and compression-based techniques to reduce communication bandwidths for SAR-based wide area search platforms to SATCOM-supportable bandwidths. The approach uses statistical representation of the background to perform aggressive compression, and wavelet-based approaches to compress detected targets to maintain signature fidelity.

(U) The purpose of the Sensor to Shooter to Weapon (SSW) program is to dramatically increase the probability of kill for air to mobile and moving target missions by integrating intelligence, surveillance, and reconnaissance (ISR), shooters, and weapons with closed loop control, dynamically allocated and assigned by complex, adaptive planning and scheduling. Through the development and application of advanced hybrid control algorithms to the mission planning and target selection (allocation) process and to the sensor/shooter/weapon assignment process, the overall timeline from target detection to weapon impact will be dramatically compressed. Further, this effort will enable the dynamic assignment of directable weapons (e.g., cruise missiles) which will provide the capability for re-assignment of near-launch and post-launch weapons to secondary targets, improving the weapon to target kill ratio and reducing the cost and logistics pipeline for a given target set.

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(U) The Continuous Ground Vehicle Tracking (CGVT) program will monitor the positions of military forces and vehicles regardless of terrain masking, stop-and-go behavior, and nearby traffic. CGVT will exploit multiple synthetic aperture radar and ground moving target indicator radars synergistically to maintain constant awareness of ground vehicles dispersed over a wide area and for an extended period of time. The following technologies will be developed to accomplish this goal: automatic target verification (ATV) employing ATR techniques with the added constraints available through continuous tracking; extended monitoring frameworks that combine moving target trackers with stationary target monitoring techniques; and dynamic resource management to collect the right data at the right time. The program will culminate in 2002 with an integrated demonstration of tracking 100 vehicles maneuvering within a 10,000 km<sup>2</sup> playbox over a 24-hour period.

(U) The Force Protection Ground Moving Target Identification (GMTI) program will explore the feasibility of using fiber-optically remoted, lightweight antenna technology to develop a lightweight, easily deployable moving target monitoring system. The objective is to be able to detect and locate moving objects at significant distances (kilometers) in and out of foliage. The challenge is to reach sufficient sensitivity and clutter rejection to detect personnel, thereby serving as a sensing option for alternatives to land mines and providing situational awareness information to facilities/garrisoned troops located near or in foliage.

(U) The Moving Target Exploitation (MTE) program's objective is to provide significant improvements to the exploitation of ground Moving Target Indicator (MTI) radar data by providing previously unavailable capabilities to automatically detect, track, and classify high-valued ground-moving targets and maneuvering formations using all-weather airborne surveillance radar data. Four techniques are being investigated and evaluated: the automatic tracking of ground moving vehicles; the automatic analysis of moving vehicle motion patterns and behavior patterns to identify purposeful military movement; the discrimination of desired targets from other moving vehicles using high range resolution (HRR) MTI range profiling and 1-D automatic target recognition; and the imaging of specific moving targets via enhanced moving target imaging (MTIm) processing. Specific applications are targeted for MTI sensors on board the Joint Surveillance, Target, and Attack Radar System (Joint STARS), U-2, and Global Hawk platforms. In addition, system-level approaches for the application of complex-data techniques will be investigated, developed and integrated, including scatterer-specific imaging (SSI) for enhanced ATR with reduced false-alarm rates and systematic applications of coherent change-detection (CoCD).

(U) The goal of the Airborne Video Surveillance (AVS) program is to build and evaluate Airborne Video Surveillance technology to increase the tactical usefulness of video (visible and infrared) data from Unmanned Air Vehicles (UAVs). The following semiautomatic capabilities will be developed: Precision Video Registration (PVR): the real-time geolocation (2-10 meter accuracy) of moving and stopped targets in airborne video imagery using precision geo-referenced orthomosaics as reference imagery; Activity Monitoring (AM): the reliable detection of specific events

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(soldier incursion, removal of vehicles from cantonment areas, etc.) of points, operations areas and lines of communication (LOC); and Multiple Target Surveillance (MTS): the simultaneous tracking of multiple ground vehicles (up to 12 targets) in the sensor platform area of regard but outside a single sensor field of view.

(U) The goal of the Surface Target Engagement (STE) program is to develop and demonstrate the capability to perform affordable, all-weather, precision negation of moving surface targets (both land and sea based). An integrated system of netted ground moving target indication (GMTI) sensors will be developed using existing and planned sensors to produce a precision ground moving target fire control solution. Integrated weapons system architectures will be developed and demonstrated which include netted air-to-ground GMTI sensors, fighter-based weapons, long range precision weapons, and gun launched weapons. In-flight midcourse and terminal guidance to weapons will also be explored to drive weapon system CEP's an order of magnitude below current systems against moving targets. The precise cueing from the netted GMTI sensors will allow for lower cost weapons by reducing the complexity of, or eliminating entirely, the weapon's terminal guidance seekers. Additionally, collateral damage will be minimized by virtue of the very precise targeting and midcourse/terminal phase flight updates. The STE program will begin with a thorough characterization of GMTI sensor fire control feasibility including advanced multi-sensor tracking and association algorithms, Space Time Adaptive Processing (STAP) to reduce sensor minimum detectable velocity and multi-sensor data collection/analysis to verify fire control accuracy predictions. Communications and weapons system studies will also be conducted to minimize weapon cost.

(U) The goal of the Congressionally-mandated Geographic Synthetic Aperture Radar (GeoSAR) Program is to develop and test an airborne, radar-based foliage penetration/terrain feature mapping and geographic information system with an emphasis on both defense and civil applications. This program will be completed with FY 1998 funding and transitioned to Army Topographical Engineering Center in FY 1999 for user validation.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- The Counter CC&D Program's Foliage Penetration (FOPEN) SAR completed Critical Design Review (CDR) for test and evaluation on a manned platform which will provide inputs via narrowband tactical data links to the image exploitation capabilities in a dedicated Ground Control and Display Subsystem (GCDS). The Image Exploitation techniques developed under SAIP have been extended to include unique characteristics of VHF/UHF band FOPEN radar, high spatial resolution U2 SYERS MSI sensor, and multisensor correlation to improve the reliability of detection and discrimination of tactical targets under camouflage and foliage cover. Data from the FY97

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Keystone97 Counter CC&D exercises have been processed to verify FOPEN SAR's ability to reliably detect tactical targets, georegistration of SAR with MSI and X-Band imagery, and show feasibility of meeting ADT/C objectives of 0.1 False Alarm per square kilometer. A feasibility study was carried out for adding FOPEN MTI and RFINT within the FOPEN architecture. (\$ 21.000 Million)

- The GeoSAR Program completed the development of the foliage penetration, mapping radar and integrated it on a contractor furnished aircraft. The Image Formation Processor and Geographic Information System have been baselined in preparation for user validation flight tests. (\$ 10.010 Million)
- Semi-Automated IMINT Processing (SAIP) integration and field testing continued towards transition system objectives with initial operational deployment of the enhanced SAIP system. Formal military utility assessment was conducted with Army and Air Force operational users under US Atlantic Command (USACOM) sponsorship. System assessment was conducted by a team from USACOM and the National Imagery and Mapping Agency. Enhanced SAIP capabilities were provided to support the Global Hawk UAV SAR, the U-2 ASARS-2, the U-2 SYERS sensor, and the ASARS Improvement Program. (\$ 23.893 Million)
- The MSTAR target recognition system was integrated, evaluated and matured into a 20 target system with the ability to handle articulated, obscured, realistic target imagery under a variety of operating conditions. The system used a large database of target and clutter imagery. ESC and ASC have roadmapped the intelligent bandwidth compression technology for transition to JSTARS and ASARS Improvement Program. Full prototypes for interactive exploitation for two analyst missions were developed and evaluated. A rapid target insertion prototype system was built and evaluated, creating 5 target models and rapid ATR training systems as a baseline. Resource management of the target recognition search process was prototyped and evaluated. An integrated, real-time demonstration of intelligent bandwidth compression using U2 and Global Hawk (utilizing the Sensor Emulation Platform) in support of potential SAIP or MSTAR exploitation was conducted. (\$ 15.547 Million)

- The MTE program demonstrated near-real-time operational MTE performance against high-value moving targets by integrating the classification component and simulation testbeds developed in FY 1997 into a single MTE system testbed. This testbed was exercised with recorded Joint STARS data. In parallel, more extensive tools have been developed, and exercised and evaluated in a ground station simulation testbed. A ground station simulation testbed has emulated the MTE data that will be available from the Global Hawk platform. Two advanced techniques, scatterer-specific imaging (SSI) and coherent change detection (CoCD) have been adapted to operate with the

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X-band class of radar sensors. Performance analyses for the robustness of the coherence-based techniques with X-band sensors were completed. (\$ 14.988 Million)

(U) FY1999 Plans:

- The Counter CC&D Program will complete integration of a FOPEN SAR Manned Airborne Demonstrator with a tactical data link and a Ground Control and Display System to verify Global Hawk HAE UAV performance requirements. A laboratory demonstration of the Multisensor Exploitation Testbed will be conducted in preparation for FY 2000 development tests of FOPEN and SYERS MSI Exploitation and Counter CC&D Tests. Advanced FOPEN and MSI ATD/C algorithms will be extended to provide increased georegistration accuracy and potential for reduction of false alarm density through sensor fusion Analysis of FOPEN MTI/RFINT system concepts will be combined with a FOPEN/SIGINT data collection to verify concepts. (\$ 29.700 Million)
- The SAIP Operational Assessment will be completed and the final transition configuration of system stood up. Demonstration of all software upgrades will be conducted. Interim operational capabilities will be transitioned for integration into the US Air Force flight test facility and to the Army ETRAC system. (\$ 14.267 Million)
- The evaluation of the MSTAR 20 target/full extended operating condition (EOC) system will be expanded using new data collections, including Global Hawk data (acquired through the Sensor Emulation Platform (SEP). Scalability of the system will be demonstrated by extension to a 25 target system. Technology will be integrated with SAIP and STARLOS technology, transition to a real time demonstration system will begin. Also, a three-year effort to develop a MSTAR model-driven ATR system will begin to accommodate moving targets using MTE technology. Multiple modes of radar processing (High Range Resolution, Inverse SAR, phase history) shall be utilized to improve performance on moving and stationary targets. Development and evaluation of rapid target insertion and interactive exploitation systems will continue, with key milestones occurring in FY 2000. (\$ 22.482 Million)
- The MTE Program will demonstrate and evaluate the effectiveness of MTE on-board the JSTARs T3 Testbed against a complex set (greater than 500 ground vehicles) of military vehicles. The SEP testbed will be completed and GMTI, HRR GMTI, and MTE data will be collected. The first build of the MTE-CGS ground station will be completed and demonstrated using data recorded by the SEP platform. (\$ 10.750 Million)

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(U) FY2000 Plans:

- Operational support to the Army and Air Force SAIP residual operational capability will be provided through the second quarter of FY 2000. (\$ 4.625 Million)
- The MSTAR system will become the All-STAR system (ALL-situation Taskable ATR for Radar), capable of dealing with both moving and stationary targets using a common reasoning system. The system will be able to reason about 30 different target types, where the targets can be operating under varying conditions, including motion, background, articulation, obscuration, configuration, and target manufacturing variations. Incorporating technology from the SAIP program to analyze force structure and make use of context, false alarm rates on newly collected clutter data representative of operational challenges will drop to one per 200 square kilometers. Using distributed parallel computing, a near real time system will demonstrate recognition capabilities of stationary targets. A toolkit of interactive exploitation tools integrated with commercial technology will provide useful ATR capabilities to image analysts. The rapid target model insertion project will demonstrate the ability to incorporate a new target model into the MSTAR system within two weeks, representing a five-fold improvement over 1997 baseline rates. (\$ 13.696 Million)
- The AVS program will integrate, demonstrate and evaluate airborne and laboratory systems in a simulated military mission with these technology goals: Activity Monitoring - upgrade to monitor activities (e.g. soldier movement, tactical and strategic vehicle movement) in larger areas and along extended lines of communication; Moving Target Surveillance - demonstrate increased reliability of 3 target tracking/reacquisition and scaled development to track 6 targets; Precision Video Registration - Demonstrate 2 meter RMS error geolocation accuracy on 80% of mission imagery similar to reference imagery (Class 1: less than 40 degree line of sight variation, good contrast, small seasonal variations), demonstrate similar accuracy on 75% of imagery exceeding this envelope (Class 2). (\$ 10.500 Million)
- The Sensor to Shooter to Weapon (SSW) program will initiate development of hybrid control algorithms, and demonstrate a "Shooter's Control Panel" that integrates, delivers, and displays live Intelligence, Surveillance and Reconnaissance (ISR) feeds. (\$ 3.000 Million)
- The Counter CC&D Program will complete verification of FOPEN SAR imaging and target detection on the Army RC-12 Airborne Demonstrator. Real time surveillance will be demonstrated via a tactical data link and a Ground Control and Display System. A series of tactical demonstrations will be conducted with Army and Air Force exercises to validate the operational utility of the FOPEN SAR. The

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Multi Sensor Exploitation Testbed will be utilized to project Counter CC&D Exploitation capabilities in a CIGSS compliant architecture. Concept Development studies will be completed for FOPEN MTI/RFINT. (\$30.000 Million)

- The Surface Target Engagement (STE) Program will develop and assess the technology to support affordable, precise, moving surface target engagement. Multiple platform automated tracking and association algorithms will be developed and exercised using data collecting by employing existing GMTI sensors in a coordinated simultaneous collection architecture. Advanced STAP GMTI algorithms will be developed and evaluated using multi-aperture data collected with an existing experimental asset and HRR GMTI ID capability will be assessed with recorded data. The best performing STAP and HRR ID algorithms will be evaluated for future real-time implementation. Weapon system studies will be conducted to investigate communication requirements, weapon system CEPs for a variety of weapon systems, weapon cost reduction, BM/C3 requirements, and low cost sensor to weapon link designs. (\$ 15.400 Million)
- The Force Protection GMTI program will conduct experiments to verify lateral low frequency propagation phenomenology in foliage and explore very low doppler clutter characteristics in a variety of conditions. A system study will also be conducted to determine sensor RF and physical requirements and verify detection, false alarm, and location performance predictions. (\$ 3.349 Million)

(U) **FY2001 Plans:**

- The All-STAR system will deal with a hundred target types, using targets generated with the efficiencies afforded by the Rapid Target Model Insertion developments. The emphasis will be on maintaining an ability to treat targets under realistic conditions, and to be able to incorporate algorithmic methods that permit the tasking of collection assets to maximally improve recognition capabilities (Active ATR). For moving targets, the recognition capabilities developed in the ALL-Star project will be integrated with tracking capabilities developed elsewhere to improve recognition rates based on multiple views. Recognition capabilities will be able to fuse radar information from targets while they are moving as well as information acquired when they are stationary. To image moving targets, inverse SAR methods (ISAR) will be investigated to integrate with other information to improve recognition and decrease false alarms. (\$12.000 Million)
- The AVS program will integrate, demonstrate and evaluate airborne systems in simulated military missions with these technology goals: Activity Monitoring - increased reliability and coverage for point, area and LOC monitoring; Moving Target Surveillance: Demonstrate tracking/reacquisition of 12 targets; Demonstrate 2 meter RMS error geolocation accuracy on 90% of Class 1 and 80% of Class 2 imagery. (\$ 8.000 Million)

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- The Sensor to Shooter to Weapon (SSW) program will incorporate integrated control information into the "Shooter's Control Panel", including hybrid control theory for planning and scheduling. Incorporate applicable outputs from the Dynamic Data Base (DDB), Agile Information Control Environment (AICE), Moving Target Exploitation (MTE), and Advanced ISR Management (AIM) programs. (\$ 8.000 Million)
- The Counter CC&D Program will complete development of concepts of operation, and hold Readiness Review and Test and Evaluation review for Demonstration #3, FOPEN image interpretation with MSET at 60 sq km per minute at 40 km range, and demonstrate operational detection of user-specified threats at .01 FA per sq km. (\$ 23.753 Million)
- The Surface Target Engagement (STE) Program will continue the development of affordable surface moving target engagement architectures. The weapon system study and fire control accuracy experiments will be completed. The required weapon, data link, and GMTI sensor modifications will begin. Analyses and simulations will continue to demonstrate STE concept for deep targeting. An initial demonstration of STE using manned aircraft will be conducted. Joint demonstration plans will be finalized to support integrated demonstration in FY 2002. (\$ 30.000 Million)
- The Force Protection Ground Moving Target Identification (GMTI) project will develop a prototype array for demonstration of predicted sensor performance. Demonstration plans will be formulated and critical laboratory demonstrations will be conducted. (\$ 6.000 Million)

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Sep 98	MSTAR ATR demo: 20 targets, large range of EOCs; interoperability of system with portions of SAIP.
Oct 98	GeoSAR Aircraft Modifications complete for radar installation.
Nov 98	Start Integration of FOPEN Airborne Demonstration Radar.
Feb 99	Large scale GMTI data collection with JSTARS and SEP including hundreds of ground vehicles and variable radar modes.
Apr 99	Airborne MTE demonstration with Joint STARS.

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May 99	FOPEN MTI/RFINT collection at Ft Gordon on Army Moving Targets.
Jul 99	Complete integration of SAIP transition configuration.
Jul 99	GeoSAR foliage penetration interferometric mapping validated.
Sep 99	Flight demonstration of FOPEN radar on manned platform.
Nov 99	GeoSAR Transition to user completed.
Nov 99	Final MSTAR ATR demo: 25 targets, full range of EOC's, integration with interactive exploitation tools, SEP data.
Dec 99	STE Counter Moving Target weapon system study initiation.
Jan 00	Force Protection GMTI Propagation/Clutter Experiments begin.
Mar 00	STE HRR GMTI data collection.
May 00	STE multiple platform GMTI data collection to support precision tracking.
May 00	Verification of FOPEN SAR Automatic Target Detection and Cueing.
May 00	FOPEN MTI/RFINT Concept Development Studies complete.
Jun 0	Airborne demonstration of Airborne Video surveillance technologies.
Jul 00	Participate in Army Warfighting Experiment.
Jul 00	STE Counter Moving Target airborne fire control accuracy experiment.
Sep 00	STE real-time demonstration.
Jan 01	STE fire control accuracy experiment.

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DATE September 1998									
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Total Cost
Advanced Ship-Sensor Systems MRN-02	19,597	24,788	36,998	43,464	48,396	58,696	60,696	63,696	Continuing

(U) Mission Description:

(U) The Marine Technology Program is budgeted in the Advanced Technology Development Budget Activity because its objective is to identify, develop, and rapidly mature critical advanced technologies and system concepts for maritime applications that support the following goals: 1) enhancement of the ability of US naval forces to dominate the maritime battlespace, particularly in the littoral arena; 2) improved power projection capabilities of US naval forces, particularly with respect to their ability to influence the land battle; and 3) ability to counter the threat to US personnel and platforms created by the worldwide spread of increasingly sophisticated naval technology. In particular, the growing threat of quiet diesel/electric (DE) submarines, the continuing worldwide proliferation of advanced submarine and weapons capabilities, and the easy availability of modern underwater mines all represent unique warfighting challenges encountered in the maritime arena. These threats pose the greatest challenges for operations in the restricted water, near-shore regimes that are of growing importance to US strategic considerations, and necessitate the continued development of increasingly affordable far-term solutions for enhancing the operating capability and survivability margins of US naval forces in the littoral.

(U) The Advanced Ship-Sensor Systems project provides innovative sensing technologies that allow US naval forces to maintain and improve their effectiveness in operating forward from the sea in the ever more dangerous conditions of future tactical environments. This project has three principal thrusts: 1) generation of improved maritime battlespace awareness through the development of advanced sensors capable of more completely and robustly interrogating the surrounding environment; 2) development of advanced communications capabilities to enable expanded maritime information networking; and 3) exploration of platform system approaches for increased survivability in light of these and other advanced sensor and communications capabilities, including integrated sensor/stealth solutions.

(U) The Undersea Littoral Warfare (ULW) program is developing an active acoustic system to significantly enhance the detection, classification, and targeting performance against low-observable submarines and mines in littoral areas by application of novel acoustic activation, signal processing, and targeting techniques for air, surface, or subsurface targeting. This program of acoustic activation combined with structure based target classification is being seamlessly coupled to a synergistic weapons targeting approach to provide an integrated underwater cooperative engagement capability that will greatly improve overall acquisition and targeting performance against quiet threats in littoral environments. The

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classification/receiver activities in the ULW program (particularly the innovative use of synthetic aperture processing techniques) have major applicability to mine detection, classification, and identification as well. In addition, the ULW program is conducting an extended feasibility assessment of the ability of innovative, multi-dimensional receiver arrays, when coupled with optimal processing approaches, to provide robust passive sonar solutions in shallow water.

(U) The Water Hammer program is conducting concept development for a standoff mine neutralization system consisting of a phased array of shock tubes to generate, focus, and transport to militarily important distances (tens of meters) a pressure pulse of sufficient energy to neutralize the threat (>1000 psi-msec; >2000 psi). Water Hammer has the potential for rapid, precision, in-stride lane clearance in deep or shallow water, reducing the need for high fidelity detection and classification. While the initial program focuses on mine/obstacle clearance, Water Hammer also has general utility as a close-in defense system for ships against multiple classes of subsurface threats.

(U) The Buoyant Cable Array Antenna (BCAA) program is investigating a full duplex link (transmit and receive) for data transfer and communications to/from submarines while operating at speed and depth. Technologies that may be employed to achieve high data transfer rates from a submerged condition include photonic signal and power links, enhanced antenna loading materials, adaptive array calibration, and enhanced communications protocols.

(U) The Reduced Drag/Fast Ship program is focused on the development and demonstration of technologies that will enable the design of efficient, high speed ships (greater than 75 knots) for a rapid response, long range (approximately 10,000 nautical miles unrefueled), sealift capability (2,500 tons cargo). While a hydrofoil type of architecture appears to offer the most promise, cost-effective high-speed sealift will require a significant increase over the currently achievable fuel efficiency. Therefore, this program will emphasize drag reduction, particularly, the use of air injection to reduce the level of frictional drag. Both numerical analysis and tow tank experiments will be used to determine the extent that drag can be reduced.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Continued development, planning, and testing of the proof-of-concept Anti-Submarine Warfare (ASW) Netted Search, Acquisition and Targeting (NetSAT) system at sea, incorporating a wide frequency band, autonomous, long duration, leave behind acoustic source; signal

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processing for enhanced detection and attack performance (Distant Thunder); and acoustic space-time adaptive processing. (\$ 11.400 Million)

- Conducted development of multi-frequency Interferometric Synthetic Aperture Sonar (IFSAS) for mine classification. (\$ 1.300 Million)
- Within the context of Congressionally directed efforts in Smart ASW and Sonar Space-Time Adaptive Processing (STAP) conducted development of smart ASW sensors to support Netted Search, Acquisition and Targeting (NetSAT); commenced feasibility investigation of Robust Passive Sonar (RPS) using space-time processing (STP) techniques; by conducting a sonar STP and shipping noise characterization experiment. (\$ 3.800 Million)
- Completed initial underwater mine neutralization explosive proof-of-concept experiments, successfully proving the feasibility of generating and propagating phased array pulse energy sufficient to destroy mine-like targets; completed single non-explosive source fabrication and testing; completed 2 x 2 non-explosive source array fabrication and began testing to address technology issues; initiated 4x4 non-explosive source array design. (\$ 1.900 Million)
- Conducted initial technology assessments and feasibility testing of advanced submarine communication system concepts, including signal exploitation, antenna array communications, and adaptive waveform generation. (\$ 1.197 Million)

(U) **FY1999 Plans:**

- Complete initial prototype ASW NetSAT system, incorporating acoustic space-time adaptive processing; integrated weapons control with countermeasures deconfliction; and integrated weapon/sensor signal processing approaches for enhanced attack performance. Conduct prototype testing to establish the detection-to-attack performance enhancements provided by networked approaches. (\$ 12.050 Million)
- Complete final testing of multi-frequency Interferometric Synthetic Aperture Sonar (IFSAS) for mine classification; assess processing approaches for application of synthetic aperture sonar (SAS) to short sonar arrays. (\$ 0.750 Million)

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- Complete feasibility investigation of Robust Passive Sonar (RPS) processing and array concepts, utilizing geographically referenced processing and space-time processing (STP) techniques. (\$ 3.200 Million)
- Continue non-explosive underwater energy projection technology development for mine neutralization, including fabrication and test of 4x4 source array test article. (\$ 3.900 Million)
- Conduct comparative testing of DARPA-generated multi-element buoyant cable array antenna concepts and Navy-generated single element approaches in UHF bands and assess cost/performance tradeoffs; perform phenomenology testing and Global Positioning System (GPS) and communications link risk reduction experiments at L-band. (\$ 4.000 Million)
- Reduced Drag/Fast Ship: Design and build a small scale, high speed (up to 75 knots) models for micro bubble airflow testing. Initiate design of a half scale, medium speed (35 kts) model for testing at Langley. (\$ 0.888 Million)

(U) **FY2000 Plans:**

- Update and complete development of prototype ASW NetSAT system; conduct final operational proof of concept demonstration, including an integrated detection/attack approach; coordinate transition of result to Navy. (\$ 6.600 Million)
- Initiate development of synthetic aperture sonar (SAS) processing for short sonar arrays; conduct initial performance test sequence. (\$ 2.200 Million)
- Commence development of Robust Passive Sonar (RPS) geographically referenced processing, including optimal space-time processing approaches; performance test on large fixed array. (\$ 6.400 Million)
- Design, fabricate, and demonstrate an underwater energy projection array prototype for at sea testing. This prototype will consist of a subarray of energetically meaningful number of elements, each operating at full design specifications. The prototype will be used to verify theoretical predictions, and to identify and address design issues in the Water Hammer concept. (\$ 6.500 Million)

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- Complete GPS and communications link risk reduction experiments at L-band; finalize system concept. Commence component technology development and initiate design and development of a full duplex (transmit/receive) submarine Buoyant Cable Array Antenna prototype. (\$ 7.000 Million)
- Perform design trade studies; test and evaluate drag reduction technologies; begin integration of results into a high-speed ship design. (\$ 3.000 Million)
- Conduct technology survey and assess system feasibility for an unmanned aerial vehicle (UAV) non-acoustic submarine detection system. (\$ 2.100 Million)
- Define conceptual technical approach for development of a water-breathing engine; conduct initial proof-of-concept experiments and identify principal technical challenges. (\$ 1.998 Million)
- Conduct trade study of technological approaches for piloting high speed submersible craft in restricted waters, to include both sensing and maneuvering control approaches. (\$ 1.200 Million)

(U) **FY2001 Plans:**

- Complete development of synthetic aperture sonar (SAS) processing package for short sonar arrays; conduct final performance demonstration; transition to service for system implementation. (\$ 1.900 Million)
- Complete Robust Passive Sonar performance testing; assess extensions for mobile array application; complete assessment of limits of passive sonar. (\$ 6.800 Million)
- Design, fabricate, and demonstrate at sea an operational Water Hammer prototype. This prototype will consist of the full complement of elements in an operational array, and will verify basic operational capabilities. This activity will also address system issues such as platform, propulsion, sensors (if any), and concept of operations. (\$ 7.064 Million)

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- Complete design and fabricate full duplex (transmit/receive) submarine buoyant cable array antenna (BCAA) prototype; conduct algorithm and software development for spatial and temporal adaptive communications link processor; begin final system-level integration. (\$ 8.650 Million)
- Complete evaluation and testing of drag reduction technologies; complete low drag, high speed, ship design and estimate resulting performance. (\$ 4.000 Million)
- Commence component technology development for an unmanned aerial vehicle (UAV) non-acoustic submarine detection system, emphasizing transmitter and receiver size and weight reduction; develop design for initial prototype; establish baseline-processing approach and assess performance. (\$ 6.750 Million)
- Commence technology risk reduction efforts to support development of a water-breathing engine. (\$ 4.300 Million)
- Conduct initial integration of a piloting simulator for high-speed submersible operations in restricted waters to support development of innovative display approaches and piloting data fusion; conduct proof of concept testing of advanced maneuvering control approaches. (\$ 4.000 Million)

(U)

Program Change Summary: (In Millions)

	<u>FY 1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>
Previous President's Budget	19.626	24.788	33.998	43.464
Current Budget	19.597	24.788	36.998	43.464

(U) Change Summary Explanation:

FY 1998 Decrease reflects minor repricing.

FY 2000 Increase reflects minor program repricing and application of synthetic aperture sonar (SAS) to short arrays.

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(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile:

Plan	Milestones
4QFY98	Complete final demonstration of Distant Thunder Anti-Submarine Warfare (ASW) detection system in western Pacific operations areas.
4QFY98	Complete test of 2 x 2 Water Hammer source array.
1QFY99	Conduct Netted Search, Acquisition and Targeting (NetSAT) system initial engineering checkout test.
2QFY99	Conduct at sea demonstration of a prototype space-time tactical sonar processor.
2QFY99	Complete fabrication of 4 x 4 Water Hammer source array as second test article.
3QFY99	Complete interferometric synthetic aperture sonar (IFSAS) sea test.
3QFY99	Complete quantitative feasibility assessment of geographically-referenced space-time processing approach.
3QFY99	Conduct at sea receive link testing at UHF in support of BCAA concept definition.
4QFY99	Conduct initial demonstration of prototype NetSAT system (targeting and attack only) in a controlled test range environment.
4QFY99	Complete feasibility assessment of short aperture SAS processing.
4QFY99	Complete test of 4 x 4 Water Hammer source array.
4QFY99	Finalize BCAA concept at UHF.
4QFY99	Complete scaled micro-bubble airflow testing for Fast Ship
1QFY00	Conduct initial feasibility sea test for BCAA concept at L-band.
2QFY00	Conduct PDR for Robust Passive Sonar (RPS) processor.
2QFY00	Conduct Water Hammer array prototype Preliminary Design Review.
3QFY00	Conduct CDR for short aperture SAS processor development.
3QFY00	Conduct PDR for BCAA prototype system.
3QFY00	Complete feasibility assessment for UAV-based non-acoustic ASW sensor.
3QFY00	Conduct proof of concept experiment of Water Breathing Engine concept.

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4QFY00

Conduct final NetSAT sensor-to-shooter operational demonstration including surveillance, detection, handoff, targeting and attack in a countermeasure environment.

4QFY00

Conduct initial at sea performance test of RPS processor.

4QFY00

Demonstrate initial prototype of Water Hammer Array at sea.

4QFY00

Complete Fast Ship design review.

1QFY01

Conduct CDR for RPS processor.

1QFY01

Conduct Water Hammer array prototype Critical Design Review.

1QFY01

Conduct CDR for BCAA prototype system.

1QFY01

Conduct initial at sea performance data collection experiment for ASW sensor.

2QFY01

Complete integration of initial underwater piloting simulator.

3QFY01

Conduct sea test of short aperture SAS processor.

3QFY01

Complete fabrication of BCAA prototype system.

3QFY01

Complete component risk-reduction testing for Water Breathing Engine supporting technologies.

3QFY01

Conduct proof of concept testing of advanced maneuvering approaches for submarines.

4QFY01

Complete final at sea performance testing of RPS processor.

4QFY01

Complete drag reduction concept evaluation and testing.

4QFY01

Complete initial off-line performance assessment of non-acoustic ASW sensor.

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RDT&E, Defense-wide					Land Warfare Technology						
BA3 Advanced Technology Development					PE 0603764E						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost	
Total Program Element (PE) Cost	79,319	108,490	104,413	106,376	128,500	87,000	87,000	87,000	Continuing	Continuing	
Rapid Strike Force Technology LNW-01	40,304	56,593	51,000	50,176	80,000	27,000	22,000	22,000	Continuing	Continuing	
Small Unit Operations LNW-02	39,015	51,897	53,413	56,200	48,500	60,000	65,000	65,000	Continuing	Continuing	

(U) Mission Description:

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior. Two broad efforts are being pursued in support of this objective: Rapid Strike Force Technology and Small Unit Operations.

(U) The Rapid Strike Force Technology project is developing the technologies necessary for highly mobile, covert transportation and information gathering systems to enhance U.S. early-entry capabilities. The primary thrusts of this project are the Combat Hybrid Power Systems program that is developing and demonstrating hybrid electric power and energy management systems for cavalry/scout vehicles; the Reconnaissance, Surveillance, and Targeting (RST) Vehicle program that is designing, developing and testing components and subsystems for a future lightweight, highly maneuverable manned or unmanned vehicle; the Ground Vehicle Self-Protection program; the Tactical Mobile Robotics (TMR) program that will develop mobile robotic technologies that will enable land forces to dominate battlespace using individual, or teams, of mobile robots in complex terrain; and the Mobile Tactical Operation Center program that will provide tactical commanders with current situational awareness, communications and control.

(U) The Small Unit Operations project is developing the critical technologies that will enable dispersed units to effectively perform warfighting operations that traditionally have required massed forces. Technology development efforts will focus on a comprehensive awareness capability that provides real-time, essential information for small units and individual warfighters; wireless communication technologies to permit exchange of voice, digital and video data with other systems; geolocation technologies that provide navigation information in built-up, forested and mountainous environments; internetted tactical surveillance and targeting sensors to complement information requirements not satisfied by national, theater, and component sensor programs; and automated ultra-miniature imaging and non-imaging sensors.

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(U)	<u>Program Change Summary: (In Millions)</u>	<u>FY1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>
	Previous President's Budget	80.924	108.490	93.413	89.700
	Current Budget	79.319	108.490	104.413	106.376
(U)	<u>Change Summary Explanation:</u>				
	FY 1998	Decrease reflects minor repricing and SBIR reprogramming.			
	FY 2000-2001	Increases reflect addition to Mobile Tactical Operation Center; initiation of Virtual Strike program; repricing of the TMR Program; and completion of the Combat Hybrid Power Systems Program in FY 2001.			

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RDT&E, Defense-wide					Land Warfare Technology						
BA3 Advanced Technology Development					PE 0603764E, Project LNW-01						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Rapid Strike Force Technology LNW-01	40,304	56,593	51,000	50,176	80,000	27,000	22,000	22,000	Continuing	Continuing	

(U) Mission Description:

(U) The emerging US vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient, land forces. This project is developing technologies that enable mobile and survivable systems for efficient command and control, mobility, surveillance, targeting and reconnaissance, which are important aspects of an early-entry capability. The project consists of: Combat Hybrid Power Systems (CHPS); Helicopter Active Noise and Vibration Control (HANVC); Reconnaissance, Surveillance, and Targeting Vehicle (RST-V); Tactical Mobile Robotics (TMR); Virtual Strike; Ground Vehicle Self-Protection; and a Mobile Tactical Operation Center (M-TOC). The CHPS, RST-V, M-TOC and TMR programs are closely coordinated with the US Army, Navy, and Marine Corps, and with DARPA's Electric Vehicle (EV-01) and Small Unit Operations (LNW-02) projects.

(U) The Combat Hybrid Power System program will develop enabling technologies and conduct demonstrations of an integrated hybrid electric power system that provides power and energy management for all of the electric subsystems throughout future combat vehicles. The hybrid electric power system will consist of an engine/alternator, sized for average power demand, energy storage and power averaging components which provide both continuous and pulsed power, distribution networks, subsystem controls, and power conditioning devices. Vehicles will be simulated to evaluate subsystem requirements, topologies, and military utility. Hybrid electric power is an essential enabling technology for future combat vehicles given the number of electrically powered subsystems planned for implementation. The vehicles will also have greatly reduced noise and thermal signatures; and improved mobility, survivability, lethality, and fuel economy. By eliminating rigid connections between components, interior layout can be optimized, significantly reducing volumetric constraints. These advantages will result in deployable, affordable combat vehicles that meet mission requirements.

(U) The HANVC program will design, fabricate and demonstrate an Active Rotor Control (ARC) system that should achieve 10dB radiated sound pressure noise reduction, and cancel vibration and noise from the main transmission to reduce maintenance costs and improve passenger comfort.

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(U) The Reconnaissance, Surveillance, and Targeting Vehicle (RST-V) program will design, develop, test/demonstrate, and transition to the Services a minimum of two hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles capable of V-22 internal transport. The vehicle will incorporate technological advancements in the areas of integrated survivability techniques and advanced suspension. The vehicle will also host integrated precision geolocation, communication and RST sensor subsystems. Vehicle design efforts will take into consideration, to the extent possible, related technologies evolving from DARPA's Small Unit Operations Project. The RST-V platform will provide a mobile quick deployment and deep insertion capable, multi-sensor, battlespace awareness asset for small unit tactical reconnaissance teams, fire support coordinators, and special reconnaissance forces. Critical components and technologies include a high efficiency, reduced signature hybrid electric propulsion system with increased fuel economy; an advanced suspension to increase cross-country speed, and provide platform stabilization; an advanced integrated survivability suite; and the capability to operate in either a silent watch/silent movement or mechanical mode. The vehicle will incorporate modularized design components to allow for signature management and rapid reconfiguration for mission tailoring and multiple purpose utility. Hardware and lessons learned from this program directly support the Marine Corps-Navy ELB ATD as well as address Joint USMC-SOCOM requirements for the Light Strike Vehicle and TV-RSTA program and HMMWV upgrades. The Marine Corps will develop vehicle concepts and chassis, integrate the DARPA developed components, and conduct vehicle performance tests (PE 0603640M) through participation in scheduled Advanced Warfighting Experiments (AWEs) and Advanced Concept Technology Demonstrations (ACTDs) (e.g. Capable Warrior).

(U) The Tactical Mobile Robotics (TMR) program will develop mobile robotic technologies that will enable land forces to dominate battlespace through employment of mobile semi-autonomous robot teams performing challenging missions in complex environments (dynamic urban areas, rugged terrain with high obstacle clutter, etc.). TMR will provide DoD organizations with semi-intelligent, cooperating platforms carrying a variety of integrated mission payloads required to conduct activities in risk intensive or inaccessible areas. Operational emphasis is on urban environments and denied areas. Specific robot technologies that will be advanced include: perception, autonomous operation, and advanced locomotion for complex obstacle negotiation. Perception capabilities will include: (a) an on-board multi-sensor perception system capable of detecting at least 80 percent of decimeter-scale terrain hazards and at least 95 percent of meter-scale terrain hazards, both at 20 Hz and (b) multi-source mapping algorithms capable of creating topological maps of urban structures with 90% accuracy. Autonomous operation capabilities will include: (a) coordination of the tactical behavior of a multi-robot team with significant command cycle reduction, and (b) traversal of rugged/complex terrain using 1 command per 100m of travel. Locomotion capabilities will feature portable (sub-meter-scale) vehicles traveling up to 1 m/s over 25 cm steps and decimeter-scale rubble.

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- (U) The Ground Vehicle Self-Protection (GVSP) program will develop an Ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.
- (U) The Virtual Strike program will develop and demonstrate technologies for low cost, deployable communications deception nodes to support dispersed forces. Virtual Strike will employ situational awareness tools to locate and identify enemy and friendly forces, a network of communications spoofing devices to deceive the enemy as to the location and tempo of U.S. forces, electronic warfare techniques to mask U.S. systems or inject false targets into enemy sensor systems, and small autonomous vehicles to support the deployment and movement of the communications and electronic warfare devices. The first phase shall develop concepts for communications deception components that can be adapted to mobile or fixed host platforms.
- (U) The Mobile Tactical Operation Center (M-TOC) program will enable the battalion commander to control organic surveillance assets and fire support while on the move. In addition, battlefield situational awareness will be provided by connectivity to division and/or corps operations centers. This program will develop the technology needed to allow high-performance exploitation and fusion of varied data products by the commander. Active electromechanical suspension, biological remedies, and various display technologies will be investigated to mitigate human performance degradation due to motion. Hybrid-electric power will be explored to provide increased power and mobility and phased-array antennas will be investigated to decrease the radar cross-section of the vehicle and to provide connectivity to satellite and airborne nodes. Enhanced visualization and communication programs currently on-going at DARPA will be leveraged.

(U) Program Accomplishments and Plans:

(U) FY1998 Accomplishments:

- Combat Hybrid Power Systems (CHPS). (\$ 18.720 Million)
  - Initiated simulation/modeling efforts using specifications for laboratory demonstration hardware to enable hardware-in-the-loop demonstration of virtual prototype.
  - Selected and procured hybrid electric power system subsystems for installation in the laboratory.
  - Developed technology and initiated fabrication of selected full-scale engine/alternator, power averaging, power conditioning, and power distribution and control components.

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- Helicopter Active Noise and Vibration Control (HANVC) program. (\$ 5.280 Million)
  - Fabricated a Mach scale actively controlled rotor for wing tunnel testing.
  - Tested active transmission mounts on a benchtop rig.
  - Conducted near full scale fixed wing testing of an actively controlled rotor.
  - Conducted testing of eddy current vibration sensors.
- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). (\$ 5.610 Million)
  - Successfully completed Preliminary Design and conducted Preliminary Design Review for both RSTV contractors.
  - Conducted critical item demonstrations of hybrid electric power system, mobility subsystems, and survivability suites.
  - Released Draft Phase II solicitation.
- Tactical Mobile Robotics (TMR). (\$ 10.694 Million)
  - Developed advanced employment concepts for Tactical Mobile Robots.
  - Refined program plan to incorporate emerging user desires and more challenging mission profiles.
  - Developed basic tele-operated stair climbing platform to support development of advanced multi-input mapping capabilities.

(U) FY1999 Plans:

- Combat Hybrid Power Systems (CHPS). (\$ 22.000 Million)
  - Install and integrate hybrid electric power subsystem in laboratory.
  - Conduct tests that demonstrate simultaneous operation of pulsed and continuous loads in the laboratory and verify the virtual prototype models.
  - Complete development of critical enabling technology for advanced, high risk power system components.
  - Demonstrate hardware-in-the-loop future combat vehicle virtual prototype to support technology development.
- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). (\$ 9.000 Million)
  - Complete Critical Design and conduct Critical Design Review of both RSTV team designs.

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- Down select to one contractor.
- Fabricate and demonstrate critical RST-V subsystems including: power system, propulsion, suspension, survivability, and controls.
- Tactical Mobile Robotics (TMR). (\$ 21.593 Million)
  - Refine advanced employment concepts to accommodate expanded user input.
  - Demonstrate breadboard robot perception, autonomy, and obstacle negotiation (stair climbing) in challenging mission scenarios.
  - Complete and evaluate competing designs for integrated robotic system.
  - Refine system design and employment plans to exploit progress made with enabling technologies and accommodate multiple collaborating platform employment where practical.
- Ground Vehicle Self-Protection Program (GVSP). (\$ 4.000 Million)
  - Initiate development of an Ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

(U) FY2000 Plans:

- Combat Hybrid Power Systems (CHPS). (\$ 6.100 Million)
  - Continue test and evaluation of fully integrated hybrid electric power system and subsystems.
  - Continue test and evaluation of advanced, high-risk hybrid electric power system components in a laboratory demonstration.
  - Initiate transition of CHPS program to U.S. Army.
- Ground Vehicle Self-Protection Program (GVSP). (\$ 6.000 Million)
  - Demonstrate low defect epitaxial material compatible for photodetectors with high sensitivity operating in the solar-blind region of the spectrum (240-300 nm).

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- Virtual Strike. (\$ 2.000 Million)
    - Develop a system concept, define system architecture, and estimate performance against threats. Build a brassboard counter communications prototype and bench test against Small Unit Operations (SUO) radio equipment. Determine optimum deployment methods.
  - Mobile Tactical Operations Center (M-TOC). (\$ 8.800 Million)
    - Assess vibration suppression needed to migrate human performance degradation due to motion.
    - Assess performance of advanced display technologies in moving platform.
    - Develop requirements for connectivity, exploitation, and interface protocols.
    - Initiate development of a lightweight phased array antenna to be incorporated into the vehicle.
  - Tactical Mobile Robotics (TMR). (\$ 18.800 Million)
    - Initiate development of fully functional tactical robotic systems.
    - Integrate enabling technologies into functional platforms.
    - Refine demonstration and transition plans commensurate with success in system design and multi-platform collaboration.
  - Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). (\$ 9.300 Million)
    - Contractor technical testing of a minimum of two completed ATD platforms to assess compliance with system capabilities document in the areas of mobility, fuel efficiency, survivability, and RST/C4I performance.
- (U) **FY2001 Plans:**
- Combat Hybrid Power Systems (CHPS). (\$ 5.676 Million)
    - Complete test and evaluation of fully integrated hybrid electric power system and subsystems.
    - Complete test and evaluation of advanced, high-risk hybrid electric power system components in a laboratory demonstration.
    - Transition CHPS program to U.S. Army.

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- Ground Vehicle Self-Protection Program (GVSP). (\$ 4.000 Million)
  - Demonstrate solar-blind detector array with 128 x 128 pixels.
- Mobile Tactical Operations Center (M-TOC). (\$ 16.000 Million)
  - Continued phased array antenna for low radar cross-section communication.
  - Integrate advanced displays into test vehicle.
  - Procure active electromechanical suspension system to meet needed vibration suppression.
  - Perform field exercise to validate test system meets human performance specifications.
- Virtual Strike. (\$ 5.000 Million)
  - Integrate equipment into platform, build three to five integrated systems, and conduct proof of concept field test in conjunction with SUO field tests.
- Tactical Mobile Robotics (TMR). (\$ 13.000 Million)
  - Complete integrated robotic system development and testing.
  - Conduct operational demonstrations with integrated systems.
  - Initiate transition to DoD acquisition programs and technology transfer to other organizations and interested entities.
- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). (\$ 6.500 Million)
  - Complete government demonstration/acceptance testing and participation in Advanced Warfighting Experiment (AWE).

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## (U) Other Program Funding Summary Cost:

		<u>FY1998</u>	<u>FY1999</u>	<u>FY2000</u>	<u>FY2001</u>
PE 0603640M	Marine Corps Advanced Technology	2.7	2.8	3.0	2.7
PE 0603005A	Combat Vehicle and Automotive Advanced Technology	1.0	1.0	5.0	3.0

## (U) Schedule Profile:

<u>Plan</u>	<u>Milestones</u>
Sep 98	Begin wind tunnel tests of the Mach-scale active rotor system for HANVC.
Sep 98	Conduct S-76 demonstration of an active transmission mount for HANVC.
Sep 98	Test RST-V critical components.
Sep 98	Finish perception, autonomous navigation, & locomotion technology breadboards (Tactical Mobile Robotics (TMR)).
Oct 98	Complete simulators and procedures for dual-fuel Molten Carbonate Fuel Cells (MCFC) power plant.
Nov 98	Conduct Reconnaissance, Surveillance, and Targeting Vehicle (RST-V) critical design review.
Dec 98	RST-V contractor downselection.
Dec 98	Complete integration of initial hardware into near-term combat hybrid power system integration lab (SIL), including test plan.
Jun 99	Demonstrate hardware-in-the-loop virtual prototype of combat hybrid power system (CHPS).
Aug 99	Complete design of robotic perception, autonomous navigation, and locomotion technology brassboards (TMR).
Sep 99	Define system design for selected operational demonstration (TMR).
Oct 99	Demonstrate RST-V rolling chassis and vehicle subsystems.
Dec 99	RST-V Contractor testing to verify: mobility, survivability, C4I, and hybrid power performance metrics.
Jan 00	Conduct Preliminary Design Review (PDR) of robotic perception, autonomous navigation, and locomotion technology brassboards and begin fabrication of same (TMR).
Mar 00	Integrate advanced components and demonstrate fully integrated combat hybrid power system laboratory (CHPS).
Jun 00	Complete assessment of human performance degradation due to motion (M-TOC).
Jul 00	Conduct Critical Design Review (CDR) of robotic perception, autonomous navigation, and locomotion technology brassboards and begin fabrication of same (TMR).
Jul 00	Define communication deception node system architecture.
Sep00	Assemble subsystems and integrate into Marine Corps RST-V chassis.
Sep 00	Initiate designs for low radar cross section antenna and electromechanical suspension system (M-TOC).
Mar 01	Configure system for Service transition (CHPS).
Mar 01	Demonstrate 4-ton RST vehicle system capabilities in Advanced Warfighting Experiment (AWE).
Mar 01	Demonstrate Avalanche Photodetector (APD) array with 100 amps/watt responsivity and low dark current.

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Jul 01

Assess human performance degradation in field exercise with electromechanical suspension and first generation C2 hardware (M-TOC).

Jul 01

Complete design of selected communications deception node components.

Jul 01

Complete operational demonstrations of Tactical Mobile Robotic systems. Initiate transition and technology transfer plans (TMR).

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY					R-1 ITEM NOMENCLATURE						
RDT&E, Defense-wide					Land Warfare Technology						
BA3 Advanced Technology Development					PE 0603764E, Project						
					LNW-02						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Small Unit Operations	39,015	51,897	53,413	56,200	48,500	60,000	65,000	65,000	Continuing	Continuing	
LNW-02											

(U) Mission Description:

(U) The Services are pursuing new tactical concepts for employing small, easily deployed units as an early entry force to address future contingencies. Their objective is to enable these forces to quickly control a large battlespace with dispersed forces, control the operational tempo, engage enemy targets with remote fire, and operate effectively across the spectrum of conflict in severe communications environments. These dismounted forces must be self-sufficient, capable of operating for several days and be sufficiently lean to be quickly inserted anywhere in the world.

(U) Superb situational awareness is critical to the combat effectiveness and survivability of such forces. Each small team must constantly know where it is, where the other teams are and where the enemy and any other threat is located. The Services are developing lightweight radio communications and Global Positioning System (GPS) dependent geo-positioning systems packaged into fielded capabilities such as the Land Warrior System. In addition, advanced standoff sensor systems such as Predator, Global Hawk, and Discoverer II are being developed to monitor the enemy's movements and characterize the battlespace. These capabilities will greatly improve the combat effectiveness of small dismounted forces, but will be limited to operations in open areas under benign conditions. Current communications, navigation and sensor technology is not capable of operating in urban areas (outside or inside buildings), in jungles, forests or mountainous terrain. Communications technology is susceptible to enemy jamming or unintentional radio interference and is not covert to intelligence operations. Extant sensors and exploitation capabilities are limited to broad area surveillance of vehicles and facilities; data is not mined and distributed to forces at the lowest echelon.

(U) The objective of the Dispersed Land Systems Program is to develop critical technologies that will enable small dismounted forces to effectively fight anywhere, anytime. The technology needs are: semi-automated maneuver and strike/fire planning and re-planning that can be employed by commanders who are physically separated but need to be virtually collocated; automated fusion and mining of information sources to provide a "bubble" of awareness over each warrior and team describing the relevant situation; accurate geographic position estimation, other than GPS, which works in all environments; and radio links and ad hoc networked communications that "glue" the components together, operates in any

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development		R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02	September 1998

environment, is covert and is resistant to interference. In addition, these technologies must not significantly increase the dismounted force's mass and power burden.

(U) The Situation Awareness System (SAS) will integrate these technologies into a 1 kg module (plus 0.5 kg per day for the power source) worn by the individual warrior. The DARPA module will be interoperable with the Army Land Warrior equipment and provide much greater functionality at significantly less weight. The warrior module will provide the communications and computing power to fully interconnect the dismounted force and enable situation awareness information to be distributed, as well as support continuous planning and combat execution. The Geolocation Technology Program will develop and demonstrate precision miniature clocks, a low-power Global Positioning System (GPS) receiver/processor (2 joules per fix) and a digital LORAN receiver to provide the accurate navigation and targeting needed for small unit operations.

(U) The Tactical Sensors Program will develop and demonstrate ultra-miniature imaging and non-imaging sensors, which can be delivered by munitions, rocket, or be hand-employed. These sensors will be highly automated and will replace manned observation posts while greatly increasing the target detection distance achieved by human observers.

(U) The Small Unit Experimental Program will investigate the critical SAS performance parameters. It will also analyze user-centered design input for developers and provide an independent assessment of the SAS design. The Experiment Program is functionally focused to evaluate the sensor employment, validate network robustness and reliability, and conduct a scenario-focused evaluation of geolocation and navigation requirements in urban, forested, and mountainous terrain. A major purpose of the Experiment Program is to acquire and codify knowledge of dispersed land forces tactics to develop decision aids. The program will evaluate the utility of planning and decision aids for small units, and information-fusion algorithms required for effective situation awareness. Specialized tools will be developed to generate scenario-synchronized data for development and evaluation of the Situation Awareness System functions. The program will coordinate the use of testing infrastructure to conduct evaluations and assessment and will employ a combination of military and technical subject matter experts, computer modeling and simulation tools, and laboratory and field exercises, to provide independent validation of the SAS functionally.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02	September 1998

(U)

Program Accomplishments and Plans:

(U)

FY1998 Accomplishments:

- Conducted field experiment of geolocation integrated brassboard system for restricted environment geolocation. (\$ 3.100 Million)
- Conducted demonstration of unique time difference of arrival breadboard for 3-meter indoor geolocation accuracy. (\$ 0.300 Million)
- Assessed advanced concepts and technologies for dispersed land forces applications. (\$ 2.200 Million)
- Conducted field experiments and demonstrated technologies at CINC and Warfighter exercises. (\$ 4.456 Million)
- Continued development of situation awareness technologies focusing on plan execution and user interface functionality. (\$ 1.500 Million)
- Continued development of tactical communications capability. (\$ 4.159 Million)
- Developed and demonstrated Situation Awareness System detailed design. (\$ 12.100 Million)
- Continued development of internetted remote control sensors to detect, localize and characterize targets. (\$ 2.500 Million)
- Continued development of surveillance and targeting sensors systems for dispersed operations. (\$ 8.700 Million)

(U)

FY1999 Plans:

- Assess advanced concepts and technologies for dispersed land forces applications. (\$ 3.200 Million)
- Conduct field experiments and demonstrate technologies at CINC and Warfighter exercises (\$ 5.168 Million)
- Complete developments for the situation awareness and real time tasking and control technologies. (\$ 1.700 Million)
- Complete technology development for tactical communications capability. (\$ 2.400 Million)
- Complete evaluation of enabling technologies associated with Situation Awareness System (SAS) design and conduct breadboard demonstration of critical communications and geolocation technologies. (\$ 6.000 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02	September 1998

- Complete detailed design of SAS and begin development of Situation Awareness brassboard system. (\$ 17.900 Million)
- Continue development of internetted remote control sensors to detect, localize and characterize targets. (\$ 4.829 Million)
- Continue development of surveillance and targeting sensors systems for dispersed operations. (\$ 9.700 Million)
- Initiate laser acoustic sensor development, including phenomenology modeling and breadboard design and fabrication. (\$ 1.000 Million)

(U) FY2000 Plans:

- Complete SAS detailed hardware and software design. (\$ 15.000 Million)
  - Complete development of the Individual Warfighter Situation Awareness System (IWSAS), Warfighter Tactical Associate (WTA)-Base, WTA Mobile, and Relay/Router/Beacon detailed hardware design.
  - Complete design of software modules for IWSAS, WTA-Base, WTA-Mobile, Relay/Router/Beacon, and network protocols.
- Complete Individual Warfighter/Warfighter Tactical Associate software coding. (\$ 9.000 Million)
  - Complete IWSAS, WTA-Base, WTA-Mobile, Relay/Router/Beacon, and network code development and testing.
  - Complete situation awareness (planning, tasking, sensor control, navigation, and alerts) application software coding and testing.
- Complete brassboard fabrication of the major SAS elements (IWSAS, WTA, and Relay/Router/Beacon). (\$ 3.000 Million)
- Complete development of sensor and weapon simulants for field tests. (\$ 2.000 Million)
- Integrate and perform in-house engineering tests on brassboard SAS. (\$ 2.000 Million)
- Conduct performance assessment of Situation Awareness System (SAS) Phase 3 brassboard design. (\$ 7.900 Million)
  - Verify that Individual Warfighting Situation Awareness System (IWSAS), Warfighter Tactical Associate (WTA) and Relay/Router/Beacon Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99% service availability objective.
- Measure SAS network capacity, loading factors, data rates, and protocol performance.
- Verify geolocation accuracy and navigation performance in urban and field environments.
- Assess situation awareness display functionality and human - machine interface utility.
- Develop preliminary detailed demonstration plan for FY 2001 SAS operational demonstration. (\$ 2.000 Million)
- Begin fabrication of 100 IWSAS, 10 WTA-Mobiles, 1 WTA-Base, 100 tactical sensors, and 50 tactical relay/router/beacons. (\$ 8.000 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02	September 1998

- Complete development of internetted remote control sensors to detect, localize and characterize targets; complete development of surveillance and targeting sensors systems for dispersed operations. (\$ 1.513 Million)
- Complete laser acoustic brassboard sensor and initiate brassboard development. (\$ 5.000 Million)

(U) **FY2001 Plans:**

- Complete fabrication of 100 IWS, 10 WTA-Mobiles, 1 WTA-Base, 100 tactical sensors, and 50 tactical relays. (\$ 16.000 Million)
- Integrate IWSAS, WTA-Mobile, and WTA-Base with external legacy communications, data, and sensor equipment. (\$ 7.800 Million)
- Test integrated Situation Awareness System (SAS). (\$ 2.000 Million)
- Conduct performance assessment of final SAS Phase 3 design; Measure IWSAS, WTA and Relay/Router/Beacon Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99% service availability objective. (\$ 5.500 Million)
- Complete development of detailed demonstration scenarios to test and evaluate performance of the Situation Awareness System (SAS) under operational conditions; perform set-up of SAS field demonstrations. (\$ 2.000 Million)
- Develop training materials and conduct soldier training for field demo. (\$ 1.400 Million)
- Demonstrate Situational Awareness System (SAS) performance and military utility using four tactical scenarios in field exercise with trained user. (\$ 5.000 Million)
- Complete laser acoustic brassboard and initiate 2D fieldable sensor development. (\$ 16.500 Million)

(U) **Other Program Funding Summary Cost:** Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Oct 98	Demonstrate and characterize various brassboard geolocation technologies.
May 99	Conduct Situation Awareness System (SAS) critical technology proof-of-concept demonstrations.
Jun 99	Situation Awareness System Requirements Review.
Jul 99	Demonstrate real time in-flight mini-imaging.
Jul 99	Brassboard testing and evaluation of internetted micro unattended ground sensor system.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development		R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02		

Aug 99	Brassboard demonstration of broadband targeting sight.
Aug 99	Demonstrate integrated sensors, tasking and control brassboard.
Nov 99	Demonstrate brassboard Situation Awareness System network design.
Dec 99	Demonstrate laser acoustic signal processing and wind tests.
Feb 00	Complete SAS Critical Design Review.
Mar 00	Demonstrate Miniature Infrared Camera (MIRC).
May 00	Demonstrate integrated micro-Unattended Ground Sensors (UGS) system.
May 00	Complete Situational Awareness System (SAS) software coding.
Jun 00	Complete SAS sensor and weapon simulant.
Jul 00	Complete brassboard SAS integration and test.
Sep 00	Demonstrate laser acoustic final breadboard.
Nov 00	Complete micro-UGS field tests.
Mar 01	SAS components fabricated.
Mar 01	Complete detailed field demonstration plan.
Jun 01	Conduct demonstration readiness review.
Sep 01	Demonstrate laser acoustic final brassboard.
Sep 01	Field demonstration completed.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE	September 1998
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support					R-1 ITEM NOMENCLATURE Management Headquarters PE 0605898E						
COST (In Thousands)	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost	
Management Headquarters MH-01	35,515	38,611	40,603	42,024	43,541	45,164	46,602	46,602	Continuing	Continuing	

(U) Mission Description:

(U) This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical and information security, travel, supplies and equipment, communications, printing and reproduction. In addition, funds are included for reimbursing the Military Services for administrative support costs associated with contracts undertaken on the Agency's behalf.

(U) Program Accomplishments and Plans:(U) FY1998 Accomplishments:

- Funding under this program element supported management and administration for the RDT&E programs assigned to DARPA. The majority of the funds were required for the pay of personnel who operate the Agency. The funding level reflects rental costs associated with the renegotiation of leases, and the related support and security requirements. (\$ 35.515 Million)

(U) FY1999 Plans:

- DARPA will continue to fund management and administrative support costs. The growth in Management Headquarters is due to increased salary requirements to accommodate mandated pay raises and a change in the mix between civilian and Intergovernmental Personnel Act appointments. This effort, which includes technical and academic personnel from commercial sector, has full support from the Department as evidenced by DoD legislative proposal to expand Intergovernmental Personnel Act appointments and increase funding in this program element. (\$ 38.611 Million)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters PE 0605898E, Project MH-01	September 1998

(U) FY2000 Plans:

- DARPA will continue to fund management and administrative support costs. Increased costs reflect salary requirements to accommodate mandated pay raises and continued change in the mix between civilian and Intergovernmental Personal Act appointments. (\$ 40.603 Million)

(U) FY2001 Plans:

- DARPA will continue to fund management and administrative support costs. Increased costs reflect the cost of mandated pay raises, and related security requirements. (\$ 42.024 Million)

(U) Program Change Summary: (In Millions)

	<u>FY1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>
Previous President's Budget	35.039	38.611	42.603	43.782
Current Budget	35.515	38.611	40.603	42.024

(U) Change Summary Explanation:

FY 1998 Increase reflects below threshold reprogramming adjustments to meet infrastructure contract requirements.  
 FY 2000-01 Decreases reflect Agency repricing of support infrastructure and IPA costs.

(U) Other Program Funding Summary Cost: Not Applicable.

(U) Schedule Profile: Not Applicable.

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# **SECTION III**

## **MANPOWER**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY  
 FY 2000/2001 DEFENSE BUDGET REVIEW  
 BUDGETED MILITARY AND CIVILIAN PAY RAISE AMOUNTS  
 (\$ IN THOUSANDS)

FY 1999      FY 2000      FY 2001

MILITARY PERSONNEL      N/A      0      0      0

CIVILIAN PERSONNEL  
RDT&E Defensewide  
Classified

Effective      Percent

FY 1999	1-Jan-99	313	418	418
FY 2000	1-Jan-00	0	280	374
FY 2001	1-Jan-01	0	0	282
Total		313	698	1074

TOTAL CIVILIAN PERSONNEL

313      698      1,074

**CIVILIAN PERSONNEL HIRING PLAN  
COMPONENT  
FY 1999**

**APPROPRIATION: RDT&E, DEFENSEWIDE**

Month a	E/S Beginning b	Separations					Total g	Net Change h	E/S Revised i	FTE j
		Gains c	Attrition d	Retire e	RIF f					
Oct	181	5	0	0	0	0	0	5	186	17
Nov	186	3	0	0	0	0	0	3	189	17
Dec	189	0	1	2	0	3	3	-3	186	17
Jan	186	2	1	2	0	3	3	-1	185	17
Feb	185	2	0	0	0	0	0	2	187	17
Mar	187	4	1	0	0	1	1	3	190	17
Apr	190	4	0	0	0	0	0	4	194	17
May	194	6	2	0	0	2	2	4	198	17
Jun	198	4	1	0	0	1	1	3	201	17
Jul	201	5	0	0	0	0	0	5	206	18
Aug	206	5	1	0	0	1	1	4	210	18
Sep	210	5	1	0	0	1	1	4	214	18
Total	210	45	8	4	0	12	12	33	214	207

**CIVILIAN PERSONNEL HIRING PLAN  
COMPONENT  
FY 2000**

**APPROPRIATION: RDT&E, DEFENSEWIDE**

<u>Month</u> a	<u>E/S Beginning</u> b	<u>Separations</u>					<u>Total</u> g	<u>Net Change</u> h	<u>E/S Revised</u> i	<u>FTE</u> j
		<u>Gains</u> c	<u>Attrition</u> d	<u>Retire</u> e	<u>RIF</u> f					
Oct	214	3	0	0	0	0	0	3	217	18
Nov	217	0	1	0	0	0	1	-1	216	18
Dec	216	0	1	2	0	0	3	-3	213	17
Jan	213	1	2	2	0	0	4	-3	210	17
Feb	210	2	0	0	0	0	0	2	212	17
Mar	212	2	0	0	0	0	0	2	214	17
Apr	214	0	2	0	0	0	2	-2	212	17
May	212	3	0	0	0	0	0	3	215	17
Jun	215	0	2	0	0	0	2	-2	213	17
Jul	213	2	3	0	0	0	3	-1	212	16
Aug	212	0	3	0	0	0	3	-3	209	15
Sep	209	0	1	0	0	0	1	-1	208	15
Total	209	13	15	4	0	0	19	-6	208	201

**CIVILIAN PERSONNEL HIRING PLAN  
COMPONENT  
FY 2001**

**APPROPRIATION: RDT&E, DEFENSEWIDE**

Month	E/S Beginning	Gains	Separations				Total	Net Change	E/S Revised	FTE
			Attrition	Retire	RIF					
a	b	c	d	e	f	g	h	i	j	
Oct	208	3	0	0	0	0	3	211	16	
Nov	211	0	0	0	0	0	0	211	17	
Dec	211	0	2	2	0	4	-4	207	16	
Jan	207	1	1	1	0	2	-1	206	16	
Feb	206	1	0	0	0	0	1	207	16	
Mar	207	2	0	0	0	0	2	209	16	
Apr	209	1	1	0	0	1	0	209	17	
May	209	3	1	0	0	1	2	211	17	
Jun	211	1	2	0	0	2	-1	210	17	
Jul	210	0	2	0	0	2	-2	208	17	
Aug	208	2	3	0	0	3	-1	207	16	
Sep	207	0	3	0	0	3	-3	204	16	
Total	207	14	15	3	0	18	-4	204	197	

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

CIVILIAN PERSONNEL COSTS

FY 2000/2001 Defense Budget Review

FY 1998/99/00/01

(\$ in Thousands)

DATE: September 1998

APPROPRIATION: RESEARCH AND DEVELOPMENT

OP-08 Civilian Personnel

Prior Year (PY) = 1998

DP LN	TRES CD	IT	DESCRIPTION	PY BEGIN STRENGTH	PY END STRENGTH		FULL TIME EQUIV		PY BASIC COMP	PY OVER TIME	PY HOL PAY	PY OTHER	PY TOTAL VARIAB	PY TOTAL OC 11	PY BENEFIT OC 12	PY TOTAL COST
400	50	1	Senior Executive Schedule	19	18	16	16	15	1891	0	0	301	301	2192	390	2582
400	50	3	General Schedule	123	118	112	118	116	8520	45	1	368	414	8934	1608	10542
400	50		Subtotal	142	136	128	134	131	10411	45	1	669	715	11126	1998	13124
400	50		Subtotal (Rate)						77.69403				0.06868	83.02985	0.19191	97.94030
400	50	4	Special Schedule	50	45	45	50	50	7690					7690		7690
400	50		IPA (Rate)						153.80000					153.80000		153.80000
400	50	18	Voluntary Separation Incentives												175	175
400	50	20	\$80 Surcharge to Retirement												11	11
400	50		Total Civilian	192	181	173	184	181	18101	45	1	669	715	18816	2184	21000
400	50		Total Civilian (Rate)						98.37500				0.03950	102.26087	0.12066	114.13043

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

CIVILIAN PERSONNEL COSTS

FY 2000/2001 Defense Budget Review

FY 1998/99/00/01

(\$ in Thousands)

DATE: September 1998

APPROPRIATION: RESEARCH AND DEVELOPMENT

OP-08 Civilian Personnel

Current Year (CY) = 1999

DP LN	TRES CD	IT	DESCRIPTION	CY BEGIN STRENGTH	CY END STRENGTH		FULL TIME EQUIV		CY BASIC COMP	CY OVER TIME	CY HOL PAY	CY OTHER	CY TOTAL VARIAB	CY TOTAL OC 11	CY BENEFIT OC 12	CY TOTAL COST
400	50	1	Senior Executive Schedule	18	24	22	22	21	2625	0	0	330	330	2955	433	3388
400	50	3	General Schedule	118	120	115	117	115	8685	50	1	404	455	9140	1728	10868
400	50		Subtotal	136	144	137	139	136	11310	50	1	734	785	12095	2161	14256
400	50		Subtotal (Rate)						81.36691				0.06941	87.01439	0.19107	102.56115
400	50	4	Special Schedule	45	70	70	68	68	10962					10962		10962
400	50		IPA (Rate)						161.20588					161.20588		161.20588
400	50		Total Civilian	181	214	207	207	204	22272	50	1	734	785	23057	2161	25218
400	50		Total Civilian (Rate)						107.59420				0.03525	111.38647	0.09703	121.82609

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

CIVILIAN PERSONNEL COSTS

FY 2000/2001 Defense Budget Review

FY 1998/99/00/01

(\$ in Thousands)

DATE: September 1998

APPROPRIATION: RESEARCH AND DEVELOPMENT

OP-08 Civilian Personnel

Budget Year (BY1) = 2000

DP LN	TRES CD	IT	DESCRIPTION	BY BEGIN STRENGTH	BY1 END STRENGTH	FULL TIME EQUIV		BY1 BASIC COMP	BY1 OVER TIME	BY1 HOL PAY	BY1 OTHER	BY1 TOTAL	BY1 TOTAL	BY1 BENEFIT	BY1 TOTAL	BY1 COST
					TOTAL	FTP	TOTAL	FTP			OC 11	VARIABLE	OC 11	OC 12		
400	50	1	Senior Executive Schedule	24	23	21	21	20	2581	0	0	250	250	2831	415	3246
400	50	3	General Schedule	120	105	101	102	100	7799	48	1	277	326	8125	1661	9786
400	50		Subtotal	144	128	122	123	120	10380	48	1	527	576	10956	2076	13032
400	50		Subtotal (Rate)						84.39024			0.05549	89.07317	0.20000	105.95122	
400	50	4	Special Schedule	70	80	80	78	78	13182				13182		13182	
400	50		IPA (Rate)						169.00000				169.00000		169.00000	
400	50		Total Civilian	214	208	202	201	198	23562	48	1	527	576	24138	2076	26214
400	50		Total Civilian (Rate)						117.22388			0.02445	120.08955	0.08811	130.41791	



DEFENSE ADVANCED RESEARCH PROJECTS AGENCY  
CIVILIAN PERSONNEL COSTS  
FY 2000/2001 Defense Budget Review  
FY 1998/99/00/01  
(\$ in Thousands)

DATE: September 1998

APPROPRIATION: RESEARCH AND DEVELOPMENT

OP-08 Civilian Personnel

Budget Year Plus One (BY2) = 2001

DP LN	TRES CD	IT	DESCRIPTION	BY1 BEGIN STRENGTH	BY2 END STRENGTH		FULL TIME EQUIV		BY2 BASIC COMP	BY2 OVER TIME	BY2 HOL PAY	BY2 OTHER	BY2 TOTAL VARIAB	BY2 TOTAL OC 11	BY2 BENEFIT OC 12	BY2 TOTAL COST
400	50	1	Senior Executive Schedule	23	23	21	21	20	2669	0	0	280	280	2949	427	3376
400	50	3	General Schedule	105	101	97	98	96	7718	51	1	267	319	8037	1651	9688
400	50		Subtotal	128	124	118	119	116	10387	51	1	547	599	10986	2078	13064
400	50		Subtotal (Rate)						87.28571				0.05767	92.31933	0.20006	109.78151
400	50	4	Special Schedule	80	80	80	78	78	13826					13826		13826
400	50		IPA (Rate)						177.25641					177.25641		177.25641
400	50		Total Civilian	208	204	198	197	194	24213	51	1	547	599	24812	2078	26890
400	50		Total Civilian (Rate)						122.90863				0.02474	125.94924	0.08582	136.49746

**SECTION IV**

**OTHER REQUIRED EXHIBITS**

# Advisory and Assistance Services

PB-15 Exhibit

## DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Appropriation: RDT&E Defense-wide	FY 1998 Actuals	(Dollars in Thousands)			FY 2001 Estimate
		FY 1999 Estimate	FY 2000 Estimate	FY 2000 Estimate	
I. Management & Professional Support Services					
FFRDC Work	650	600	600		600
Non-FFRDC Work	47,000	43,100	42,500		41,900
Subtotal	47,650	43,700	43,100		42,500
II. Studies, Analysis, & Evaluations					
FFRDC Work	7,950	7,100	7,000		6,900
Non-FFRDC Work	5,920	4,600	4,400		4,200
Subtotal	13,870	11,700	11,400		11,100
III. Engineering & Technical Services					
FFRDC Work	0	0	0		0
Non-FFRDC Work	0	0	0		0
Subtotal	0	0	0		0
<b>TOTAL</b>	<b>61,520</b>	<b>55,400</b>	<b>54,500</b>		<b>53,600</b>
<b>FFRDC Work</b>	<b>8,600</b>	<b>7,700</b>	<b>7,600</b>		<b>7,500</b>
<b>Non-FFRDC Work</b>	<b>52,920</b>	<b>47,700</b>	<b>46,900</b>		<b>46,100</b>

Note: DARPA estimates an decrease in A&AS contracts of approximately 10% from FY98 to FY99.  
This reflects a projected decrease in programs with significant A&AS support.

Prepared by: J. King  
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9/3/98

## DEPARTMENT OF DEFENSE MANAGEMENT HEADQUARTERS AND HEADQUARTERS SUPPORT ACTIVITIES

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**

	FY 1998 Actual				FY 1999 Estimate				FY 2000 Estimate				FY 2001 Estimate			
	Mil	Avg	Civ	Total	Mil	Avg	Civ	Total	Mil	Avg	Civ	Total	Mil	Avg	Civ	Total
	Str	FTEs	Mpwr	Oblig (\$000)	Str	FTEs	Mpwr	Oblig (\$000)	Str	FTEs	Mpwr	Oblig (\$000)	Str	FTEs	Mpwr	Oblig (\$000)
<b>Departmental Activities</b>																
<b>Military Services</b>																
<b>Military</b>																
U.S. Army	3		3	227	3		3	228	3		3	235	3		3	242
U.S. Navy	4		4	318	3		3	245	3		3	252	3		3	257
U.S. Air Force	12		12	910	12		12	928	12		12	941	12		12	965
			19	1,455			18	1,401			18	1,428			18	1,464
<b>Defense Agencies</b>																
<b>RDT&amp;E Defensewide</b>																
<b>Civilian</b>																
Direct Hire (Hdqtrs)	51		51	4,899			50	4,955			49	4,999			48	5,062
Direct Hire (Non Hdqtr)	83		83	8,411			89	9,301			74	8,033			71	8,002
IPAs	50		50	7,690			68	10,962			78	13,182			78	13,826
Other Costs				14,515				13,393				14,389				15,134
	184		184	35,515			207	38,611			201	40,603			197	42,024
<b>GRAND TOTAL</b>																
	203		203	36,970			225	40,012			219	42,031			215	43,488

Increase reflects adjustments to meet infrastructure contract requirements and mandated salary pay raises.

POC: Frankie Moran Phone: 696-2415  
Date: September, 1998

Exhibit PB-22

**DEFENSE ADVANCED RESEARCH PROJECTS AGENCY**  
**SUMMARY OF FUNDS BUDGETED FOR ENVIRONMENTAL PROJECTS**  
**FY 2000/2001 BUDGET ESTIMATE SUBMISSION**  
 (\$, Thousands)

<b>Environmental Security Technology</b>		<b>FY 1998</b>	<b>FY 1999</b>	<b>FY 2000</b>	<b>FY 2001</b>	<b>Change</b>
		<b>Actual</b>	<b>Estimate</b>	<b>Estimate</b>	<b>Estimate</b>	<b>FY 99/00 FY 00/01</b>
Appropriation:	RDT&E Defense-wide					
1. Cleanup	Not Applicable					
2. Compliance	Not Applicable					
3. Pollution Prevention	BA2 - Applied Research: Thin Film Coatings Program	3,244	2,524	345	0	-2,179 -345
4. Conservation	Not Applicable					
Total		3,244	2,524	345	0	-2,179 -345

**Justification for Changes** The funding changes reflect contractual requirements. DARPA environmental efforts end in FY 2000.